Reference
NBS Publi-cations
NAT'L INST. OF STAND & TECH R.I.C.
A11105 087154

NBSIR 80-2116

A11101 730412

Dimensional Considerations in Solar Installations

Hans J. Milton

Building Economics and Regulatory Technology Division
Center for Building Technology
National Engineering Laboratory
National Bureau of Standards
U.S. Department of Commerce
Washington, D.C. 20234

September 1980

Prepared for

Department of Energy
Office of Solar Applications for Buildings
Office of the Assistant Secretary
Conservation and Solar Applications
Washington, D.C. 20585

QC
100
.U56
80-2116
1980

NATIONAL BUREAU
OF STANDARDS
LIBRARY
MAY 13 1981

NBSIR 80-2116

DIMENSIONAL CONSIDERATIONS IN SOLAR INSTALLATIONS

Hans J. Milton

Building Economics and Regulatory Technology Division
Center for Building Technology
National Engineering Laboratory
National Bureau of Standards
U.S. Department of Commerce
Washington, D.C. 20234

September 1980

Prepared for
Department of Energy
Office of Solar Applications for Buildings
Office of the Assistant Secretary
Conservation and Solar Applications
Washington, D.C. 20585

U.S. DEPARTMENT OF COMMERCE, Philip M. Klutznick, *Secretary*

Luther H. Hodges, Jr., *Deputy Secretary*
Jordan J. Baruch, *Assistant Secretary for Productivity, Technology, and Innovation*

NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

TABLE OF CONTENTS

ABSTRACT

This Report contains a study of dimensional considerations in solar installations using non-integrated flat plate collectors. Special attention is given to sizes of collectors and their constituent materials, to dimensions that affect the collector array, and to volumetric sizes of thermal storage tanks.

One of the aims of the investigation was to assess the scope for future standardization of collector sizes and their configurations, with the object to facilitate the processes of collector design, production and distribution; as well as system design, installation, operation and maintenance. An assessment was also made of the potential impacts of a change to metric units and product sizes in the U.S. manufacturing industry.

The major portion of the report deals with a listing and evaluation of dimensional data for 185 flat plate collectors in production and/or use in the United States in 1978 (141 liquid, 37 air, 8 special types), produced by 152 different manufacturers ranging from very small to large operations. The measured perimeter dimensions of collectors cover a wide range of width/length combinations, but some trends and forcing functions can be distinguished which emphasize certain preferred "nominal" sizes, such as 48" x 96" [1220 x 2440 mm] and 36" x 78" [915 x 1980 mm], within a range of variance of approximately ±1" [±25 mm]. Solar water tanks have followed industry sizes for hot water tanks in the range 30 - 120 gallons [114 - 454 L], with a number of manufacturers offering a choice of standard sizes in this range.

To date, producers of solar systems and components have attempted only limited standardization, and more cost-effective systems could result from a shift to industry-wide size preferences. Preferred sizes, or "modules," could permit variety reduction in production and interchangeability in design and purchasing. In an analogy to other manufacturing industries, greater standardization may support an industrialized mode of operation and yield a more effective solar product range.

Key Words: Dimensions, flat plate collectors, preferred sizes, solar installations, standardization.

NOTE: In this report, certain commercial components are identified in order to provide a descriptive characterization of their features. The use of trade names or inclusion of a given component in this report in no case implies a recommendation or endorsement by the National Bureau of Standards, and the presentation should not be construed as a certification of any component. Similarly, the omission of any component does not imply that its capabilities are less than those of the included components. The report is intended to provide an overview of trends in the industry and not an evaluation of individual commercially available components.
Due to the time lag since data were collected, some products may have been modified dimensionally while others are no longer available.

Preface

This project was initiated as the result of a proposal to investigate "Dimensional Considerations in Solar Installations for Buildings Designed in U.S. Customary or Metric Units," in recognition of the potential effects of the foreshadowed change to metric (SI) units and metric product sizes in the United States. It was assumed that a change from existing dimensional preferences in building to new and slightly different preferences for design, production and construction could have an impact on the solar manufacturing industry, and that such impact should be assessed early on so that it could be taken into account in future decisions. In addition, it was considered that the change to preferred metric dimensions and product sizes could become a useful catalyst for greater standardization--especially, as many materials and components used in solar systems are produced by the building materials and components market.

During the investigation into dimensional considerations in solar systems and installations it became evident that there is little dimensional standardization of collectors, collector arrays, or related hardware in the existing solar products market. Individual manufacturers have chosen their individual sizes for collectors, based on various forcing functions, such as available materials for cover plates, collector housings, and absorber units, sizes of commercially available absorbers, and, in some instances, centerline spacings of structural building elements. The reasons given for the sizing of existing products bear witness to the absence of any industry-wide preferences that might guide manufacturers towards a more intelligent use of materials and resources, simpler configuration design, or the standardization of mounting systems and installation practices.

Compared to other, more fully developed industries the solar industry still appears to be in the pre-industrial phase with lots of small to medium size manufacturers trying many different approaches to solar energy collection and conversion.

The object of this NBSIR is to present the collection and analysis of data on dimensional considerations in solar installations, taken from existing sources. Special emphasis is given to flat plate collectors which represent the most visible and costly part of solar collection systems for low to medium temperature applications. Data are given in both U.S. customary and metric units. Key dimensional aspects are discussed and some recommendations have been made in relation to future standardization activity and other work.

Acknowledgements

In the pursuit of this investigation, dimensional considerations in solar installations have been discussed with many experts, and much useful comment was received from too many people to list individually. A special mention is made of the cooperation and assistance of Don L. Kirkpatrick, solar energy consultant, formerly of SEREF, and of C. Norman Thomas, NASA/MSFC Solar at Huntsville, Alabama, in providing technical data and comments related to this project.

Problem Significance

It is expected that active and passive solar systems will increasingly be used in connection with new or existing buildings and facilities to supplement or supplant their energy requirements, due to the rapid escalation of energy costs and potential energy shortages for conventional fuels.

It is recognized that an effective fulfillment of a significant contributing role in the national energy equation will require a different solar industry from that now in existence--an industry that can apply technological skills and mass production approaches to improve efficiency and quality, and reduce cost. An "industrialized" solar manufacturing environment would be fostered by at least some degree of standardization--the substitution of selected and rationalized approaches throughout the industry in lieu of random approaches by individual organizations. Dimensional standards do not currently exist for active solar systems, although some degree of size (volume) standardization is evident in hot water storage units for solar systems, following the standard preferences of traditional hot water storage systems.

In the absence of dimensional standardization, the design of solar systems for buildings is largely predicated upon the preselection of a particular system. This approach limits opportunities for system or component interchangeability and substitution, and may therefore impact on market factors. In the longer term, the client for the solar system has little guarantee that replacement items for his system will continue to be available, as the industry has exhibited a state of flux with manufacturers entering or leaving it, and with frequent model changes.

An additional complication is the foreshadowed change to metric (SI) units and metric preferred dimensions for building products, likely to occur during the 1980's, and already in progress in some sectors of manufacturing industry. Since many items used in solar collectors and installations are purchased from building materials suppliers, a change in dimensional preferences in that community is likely to have some effect on the solar industry. Conversely, a major change also offers opportunities, such as dimensional and other standardization in tandem with any changes that have to be made anyway. The building and construction industries have already identified dimensional coordination, based on the 100 mm building module [3-15/16"], as a major benefit and standardizing force in the metric change. Therefore, metric preferences for new modular building product sizes and building dimensions are likely to have some impact on the solar industry some years from now.

The solar industry will be confronted with an awkward, hybrid situation for some time to come. From now until the metric transition, solar collection systems will have to be designed to complement building geometry based on customary preferences, using customary materials. During the transitional phase and in a fully metric building environment, systems installed in new buildings will need to complement metric building geometry. Even in a fully metric building world it will be necessary to take into account traditional dimensional preferences in retrofit installations for pre-metric buildings.

Free-standing systems, obviously, are less affected by these trends, although individual components may change in dimensions. It is likely that the needed changes will be phased in over a lengthy period of time so that a move to metric sizes could be combined with redesign and system rationalization.

From contact with solar collector and solar system manufacturers and distributors it has become apparent that so far little attention has been paid to dimensional optimization of collectors, mounting and support systems, and other system components. Metrication is not perceived as an imminent consideration, although a number of manufacturers feature dual units in trade and technical literature, and testing laboratories carry out their performance testing to predominantly metric (SI) standards and report the test results in metric (SI) units, as provided for by ASHRAE Standard 93-77.

An indication of the industry response to a letter survey of manufacturers on "Dimensional Considerations in Solar Heating and Cooling Applications" is shown in Appendix 7. The response rate was only 25% (10 out of 40), and copies of the most significant responses are included in the Appendix.

The major thrust of this investigation is designed to identify dimensional factors for solar collectors and other major system components in current production, to ascertain whether there are any strong dimensional preferences and, where available, to provide reasons for such preferences. A further purpose is to assess the areas in which metrication is likely to impact and how.

The analysis of dimensional data for collectors and support systems from over 150 manufacturers, and technical information for other system components has illustrated the desirability of standard guidelines for the description of collector types, collector dimensions, and procedures for the verification of dimensions by measurement. The identification of preferred dimensions and sizes for system components is a worthwhile area for the voluntary national standards process. Trends in the industry now in existence point towards a variety of factors that will assist standardization and variety reduction, to gear up for the challenges and opportunities of the 1980's.

Standardization is one of the simplest means to bring about improved and guaranteed performance, stable prices with potential cost reductions, and enhanced maintainability of solar systems. For example, greater standardization could be obtained by the use of standard-size pressed metal collector housings, precoordinated for standard size absorbers and cover plates, with integral insulation, preformed or punched openings for inlets and outlets, and suitably stiffened to fit a variety of mounting configurations. Such an approach to collector manufacture would require greater capital investment but would usher in the "industrialized" era of production. As an extension of the concept, multiple collectors could be "ganged" at the factory, for delivery as a prefabricated array.

PART 1: GENERAL OBSERVATIONS

1.1 The Solar Systems and Components Manufacturing Industry

The existing solar industry comprises over 200 manufacturers of collectors and accessories, ranging from very small innovators/fabricators to large organizations, many of which are subsidiaries of major corporations engaged in the energy or manufacturing field. The industry has not yet stabilized: manufacturers enter and leave the market which is not regarded as yielding a high rate of return on investment.

Growth in the industry has been significant, primarily as a result of governmental development subsidies and demonstration programs, taxation concessions (federal and/or state), low interest loans, and a growing energy awareness in the general community. With rapidly increasing prices of conventional energy sources, the acceptance and use of solar alternatives should increase if the industry can hold or even reduce prices.

An increase in demand for solar systems would encourage larger production runs and, in some instances, economies of scale. In turn, any price reduction should attract new customers as an additional incentive. However, high general interest rates militate against investment in solar systems which have a high capital [initial] cost compared to conventional energy alternatives. Thus the industry is caught in a vicious circle.

At this stage, the solar industry can be described as a developing industry in the "pre-standardization phase." Whereas most individual systems have a manufacturing rationale, installation guidelines, and appropriate hardware, collectively the industry displays extensive variety and a lack of standardization. Industry-wide preferences, especially in dimensions and sizes, might reduce the installed cost of solar equipment, by shifting the emphasis from functional performance considerations to more logical design (such as greater integration of the system with the building envelope), simplification of installation techniques and hardware, and variety reduction in systems and system configurations. To be effective, standardization requires a partial reversal of present trends, where each manufacturer produces an "exclusive system" with individual decisions during design and production.

1.2 Entering the Solar Market

The solar industry comprises few national organizations, but many local or regional manufacturers. It appears that the larger organizations have become involved in solar activity through a diversification route, from one or more of the following commercial bases:

a. Manufacturing of metal products (aluminum, copper/brass, steel)
b. Manufacturing of glass, glazing and insulation products
c. Manufacturing of mechanical systems or components
d. Metal fabrication
e. Building systems production
f. Building construction

In addition, some solar manufacturers are subsidiaries of large multinational corporations in energy-related fields.

Smaller manufacturers of collectors and solar systems appear to have become involved from a technical base, such as:

a. Solar consulting services turned fabricators
b. Small businesses with a design or production background
c. Small contracting organizations
d. Do-it-yourself organizations or individuals from a prototype base

Solar systems production accounts for over 50% of total revenue of most smaller organizations, whereas it is generally less than 1% of revenue of large corporations. Smaller organizations enter the market with prototype systems based on their own innovative designs, and refine their products in successive applications. Larger corporations carry a significant research and development overhead directed principally at improvement of functional efficiency aspects.

The structural factors in the industry and the market background of solar manufacturers have had some impact on dimensions and sizes in current use, and they are likely to affect the future development of the solar energy industry.

1.3 Subsystems in a Solar Installation

Active solar systems can be classified into external (exposed) and internal (sheltered) components. In addition, solar systems may be subdivided into a number of subsystems for the purposes of analysis.

External Subsystem:

1a. Collection Subsystem (integral)
- Collector module or collector array (including connections)
- Flashings and waterproofing

1b. Collection Subsystem (supported)
- Collector module or collector array (including connections)
- Mounting rack or frame
- Mounting accessories and hardware

Internal Subsystems:

2. Transport Subsystem for Heat Transfer Medium and Controls:
- Pipes (liquid)
- Ducts (air)
- Insulation
- Pumps or blowers, valves, dampers, vents
- Expansion tanks, drain down tanks
- Electrical controls and gauges
- Connections and accessories

3. Thermal Storage Subsystem:
- Heat Exchanger
- Storage tank or bin
- Auxiliary heating element
- Controls and fittings

Other items not included in this abbreviated listing can generally be allocated to one of the subsystems shown.

1.4 Cost Factors and Standardization

Although cost factors in solar systems are not part of this study, they are significant inasmuch as the largest cost items in a solar installation (excluding the actual cost of installation) are the solar collectors and to a lesser extent, storage tanks or bins for the heat transfer medium. The cost of collectors generally ranges from one third to one half of the cost of the solar system package, depending upon the size of the system and the type of installation. The larger the effective collector area in a system, the greater is the percentage cost of the collectors. This can be appreciated readily when the following is considered: If the effective collection area is doubled, the cost of the collectors is approximately doubled. However, the cost of components in the transport and storage subsystems is increased at a very much smaller ratio and, sometimes, not at all; for example, there is little additional cost in increasing the capacity of pumps, actuators, valves, and other controls, and less than a doubling in the cost of suitably increased storage tanks and accessories.

For this reason, the primary emphasis in this investigation has been placed on solar collectors and potential for dimensional standardization. Already, substantial standardization is evident in heat storage systems for liquid heat transfer mediums, such as hot water tanks in the range 30 to 120 gallons, allowing for the selection of a suitable storage subsystem from a number of competing manufacturers.

Standardization efforts may be applied to all components in solar systems, but are likely to yield the highest returns to the solar industry in relation to high cost items, such as solar collectors. Standardization, combined with greater volume of production should lead to better and more economical solar products through simpler design, production, distribution, handling, and installation and better availability of suitable alternatives.

In solar systems, standardization may be applied to the following:

1. Collectors and/or collector arrays to permit structural and functional optimization of the entire system or individual components in production, purchasing, and installation. Dimensional standardization could involve length, width, thickness, inlet/outlet positions, configurations for multiple collectors, and surface area in arrays.
2. Key collector components, such as housings, cover plate(s), absorber unit, insulation jacket.
3. Mounting positions and hardware, involving brackets, support frames/racks, fasteners, etc., to facilitate installation and maintainance.
4. Pipe or duct systems for the heat transfer medium, including inlet/outlet sizes, positions, penetrations through roofs and other weatherproof surfaces, and insulation/external protection for such systems.
5. Distribution and storage systems, including air or liquid heat exchangers, pumps, actuators, blowers, valves, etc. [As noted, some degree of standardization is in evidence in solar storage tanks.]
6. System characteristics to allow the interchangeability of components from alternative sources of supply.

1.5 The Change to Metric Units of Measurement and Preferred Dimensions

The United States construction community expects to join the metric building world in the 1980's. Although there is no mandatory national metric plan, or even a firm commitment by the United States to change to the International System of Measurement--SI--various segments of manufacturing industry have developed metric conversion programs as they see the change to metric units as an inevitability. Lead sectors which will "go metric" in the early part of the 1980's are the automotive industry, the metals industries, and the chemical industry. With these changes on the horizon, is seems inevitable that other sectors, such as the building industries and the solar industry, will gradually begin to be involved in metric appraisals and, later on, work to metric plans and specifications.

The U.S. construction industries have been planning for eventual metrication [activity associated with the change to metric units] since January 1974, under the auspices of the American National Metric Council. The lead group, the Construction Industries Coordinating Committee [CICC], has developed a Construction Industries Metric Conversion Schedule, representing a timetable for a voluntary but coordinated change to SI. The key point in this schedule is the Construction Industries M-Day of January 1, 1985, which represents the first day of the metric construction year. It is proposed that metric construction materials and products will begin to enter the marketplace after this M-Day; that is, approximately five years from now. The change to metric is seen as a major, once-only opportunity to review and rationalize designs and product lines, especially by the reduction in uneconomic variety of sizes and items. It is quite likely that a number of construction materials, also widely used in the solar industry, will progressively change to new and preferred metric dimensions and properties. Already, preferred metric sizes and thicknesses for metal products have been presented in American National Standard ANSI B32.3-1977, "Preferred Metric Sizes for Flat Metal Products," which includes preferences for thickness, width and length expressed in millimeters (mm). This standard is also used in Canada under the title CAN3-G312.1-75, and many of the preferences shown are now in production. Similarly, glass sizes and thicknesses will be subject to some degree of rationalization of range and, again, Canadian standards issued under the designation CAN2-12.1-M76 to CAN2-12.10-M76, dealing with glass products, are indicative of the changes that may be expected.

A general change in building dimensions and building product sizes will occur as a result of the widespread use of the (international) building module of 100 mm (3 15/16") for structural dimensions, building geometry, and component sizes, in lieu of the customary 4-inch module (101.6 mm). Although multiples of the metric module will differ by a mere 1.6 percent from the customary preference, the change will result in a measurable reduction in larger multiples; for example, a customary preference of 4'-0" [48"], which converts to 1219 mm, will eventually become a preferred 1200 mm, which is a reduction of 19 mm or 3/4". Some solar systems can accommodate either metric or U.S. customary preferred dimensions through small adjustments in connections or joints between collectors. In general, solar collectors that will fit metric preferred dimensions should also fit customary preferred dimensions with only minor adjustments, but the reverse is rarely true.

This publication uses dual units in the presentation and evaluation of data. Testing laboratories already prepare test reports wholly or predominantly in metric units, and many manufacturers show dual units in their product literature.

1.6 The Impact of Dimensional Aspects on Collectors and Accessories

There are four broad activity areas where dimensional aspects of collectors and accessories have an impact: manufacture, design, installation, and maintenance/repair. Each activity area imposes some constraints on one or more of the others, and these interrelationships need to be fully understood to improve the dimensional compatibility of systems.

1.6.1 Dimensional considerations in manufacture relate to the following aspects:

a) dimensions and tolerances of collector - Collector housing and projections, if any.

b) arrangements and dimensions of the collector array - Coordinating dimensions for the external collector subsystem.

c) dimensions and tolerances of collector components:

i. cover plate(s)
ii. absorber plate or unit
iii. collector housing material(s)
iv. insulation material(s)
v. gaskets and selants

d) positions and sizes of inlet and outlet pipes or ducts, and projections of such pipes or ducts from the collector.

e) location of support brackets or attachments, and their projections from the housing, if any.

f) dimensions and clearances of mounting frames or racks, if any.

1.6.2 Dimensional considerations in design relate to the following aspects:

a) design of the overall collector array, allowing for necessary clearances between collectors and suitable protection against heat losses from collectors and pipes or ducts.

b) relationship of the collector array to the building, including the detailing of location, mounting, and fixing to the substructure.

c) structural performance of the collector(s) in relation to wind loads, snow loads, stresses from building movement, and impact loads.

d) detailing of penetrations through the roof or the weatherproof building envelope by pipes, ducts, cables, or fixing elements.

e) design for thermal expansion and all required clearances.

f) consideration of surface water run-off, and build-up of snow or ice below, around, and/or on top of the collector array.

g) consideration of ease of collector or component replacement, and access for cleaning, maintenance or repair.

h) integration of collectors or collector arrays into the functional building envelope.

1.6.3 Dimensional considerations in installation relate to the following aspects:

a) handling, transportation, and installation of collectors, fixing accessories, and pipes or ducts. (This frequently includes work on elevated and sloping surfaces.)

b) adjustment of support system for proper clearances, mounting angle(s), and fit

c) techniques of weatherproofing of penetrations through the roof or weatherproof building envelope and dimensional limitations

1.6.4 Dimensional considerations in maintenance or repair relate to the following aspects:

a) access and work on elevated and sloping surfaces

b) clearances required for replacement of components or entire collectors.

c) removal of individual collectors or major collector components with or without system shutdown.

d) replacement of damaged or inoperative collectors with equivalent model

The listing of dimensional factors is by no means exhaustive, and some of the factors have much greater significance and impact than others. However, the listing has been included to indicate that dimensional considerations can have a considerable impact on the utility and compatibility of solar systems with new buildings as well as in retrofit applications.

At this stage of development in the solar industry, there are many different sizes for collectors or collector arrays. The predominant trend has been for manufacturers to determine the dimensional configurations for their systems based on optimum use of collector cover and/or housing material and suitable accommodation of the absorber plate or unit, the principal ingredient of the collector.

Because the dimensions of solar collectors are not based on "standard" or preferred sizes, designers are generally locked into proprietary systems at the beginning of the design process. This reduces the procurement options. In addition, installation procedures and fixing positions and methods are in no way standardized, so that each system represents a different learning situation for designers and installers.

PART 2: SOLAR COLLECTORS AND COLLECTOR ARRAYS

2.1 General

Solar collectors form the principal external elements of a solar system. They are designed to absorb radiant solar energy, then conduct absorbed energy to a heat transfer medium (liquid or gaseous) which, in turn, is used directly or indirectly to provide or supplement the energy needs of a building or a process activity.

There are a number of approaches to solar collector design, resulting in differences in shape, size, constituent elements and materials, heat transfer mediums, performance characteristics, and installation procedures. Two broad groups of collectors can be distinguished:

i. flat plate collectors, which have a rectangular shallow box shape and utilize air or liquid as a heat transfer medium; and,

ii. concentrating collectors, which focus radiation on a small area for medium to high temperature operation, and have special shapes or tracking mechanisms for this purpose.

There are some hybrid versions which combine features, such as the use of concentrating mirrors within a rectangular shallow housing to focus radiation, and/or the use of evacuated tubes for high temperature heat transfer mediums to reduce thermal loss.

This study is concerned primarily with flat plate collectors, which normally are mounted in groups of two or more units on roofs, elevated surfaces, or at ground level, and positioned to obtain optimum efficiency of collection.

2.2 Collector Manufacture and Use

Solar collectors are manufactured in most parts of the United States, but the major producers are located in the northeastern states. Of the systems submitted in the DoE Collector Test Program, manufacturers from California and Florida predominated; however, many of these are small to medium scale operations.

The present solar industry shows some degree of climatic/geographic market segmentation. The manufacture of air collectors is concentrated in the frost/snow zones of the United States, as a preference is exhibited for units that require minimal freeze protection. Collectors using liquid heat transfer fluids are most frequently manufactured in frost-free states.

While most collectors are currently manufactured as individual panels, it has been suggested that composite modules of pre-engineered and joined collectors will reduce installation costs and difficulties by transferring the more demanding and potentially less accurate site operations to the factory although, in turn, this requires increased care in shipping and some form of mechanized handling during installation. One of the advantages of "ganged collectors" is the simplification of on-site plumbing operations, using a minimal number of connections. Ganged collectors can be pre-tested prior to installation for proper system performance and leakproof connections.

The solar designer or client at this point in time has to live with a number of uncertainties. The manufacturer of a chosen system may not continue in business, which may create problems of securing replacement items when needed due to breakage or breakdown. In addition, many manufacturers have altered their products or introduced new models, creating similar replacement concerns. The cost penalty of not having dimensionally and/or functionally compatible replacement items could be large. These potential difficulties could be exacerbated by the likely change to new and different metric sizes when the construction industry and metals industry changes to preferred metric dimensions.

Against this scenario there is considerable reluctance to make commitments to the use of capital intensive solar systems until such time as economic benefits are well proven and the industry has stabilized. It is suggested that standardization of solar products can assist the industry in this stabilization process, and provide the consumer with better and more cost-effective products.

2.3 Collector Orientation and Design of Installations

As the principal external elements in a solar system, collectors are placed to absorb or concentrate radiant solar energy, and to conduct such energy to a heat transfer medium (liquid or gaseous) which can be pumped to a heat storage unit or heat exchanger to complete the conversion process.

In the northern hemisphere, heat gain is maximized when the collector has an orientation that provides an optimum period of exposure normal or near-normal to the path of the sun. Flat plate collectors have least versatility in this regard--the mounting position can only optimize radiant heat gain for a limited period of time. The best results are obtained when the collector aperture faces as close a practicable to true south, and when the angle of tilt is equal to or slightly larger than the angle of latitude of the place of location. Some flat plate collectors with a support frame can be adjusted a number of times during the year to yield the best angle of tilt relative to the solar azimuth, and thus increase collector efficiency. Concentrating collectors provide more efficient energy collection under a wider set of conditions. The so-called "tracking collectors" can be adjusted manually or mechanically to maximize collection of energy.

The general objective in the installation of fixed solar collectors in the Northern hemisphere is to reconcile the requirements for orientation and mounting angle with existing or planned building geometry.

The preferred orientation is true rather than magnetic south. The angle of inclination of collectors should be within the range of angle of latitude (L) to angle of latitude plus 10° (L + 10°) for best results.

In many buildings, these ideal orientations are not available without the use of mounting frames or racks. In new building designs, whether or not such buildings are to be equipped with solar systems, it is useful to include some planes or sufaces that lend themselves to the subsequent incorporation or mounting of a solar system with a minimum of alterations. For design purposes, four broad types of design condition can be distinguished:

a. Integrated Design for New Buildings

In an integrated design for a new building or facility, the designer can optimize the trade-offs between building design and system selection. The solar system is normally designed to coordinate with the building design at the outset, either by full integration of the collectors with the building envelope, or by partial integration of the collector array to optimize structural and functional parameters. Integrated designs contribute to the building character and appearance, especially in south-facing portions.

b. Precoordinated Design for Delayed Installation

In a precoordinated design, it is explicitly assumed that a solar system will be installed at a later date, and that this should be achieved with a minimum of structural modification and installation effort. The criteria are similar to those for integrated designs, and certain preparations may be scheduled; for example, connections may be allowed for in the general plumbing system, and mounting fixtures may be built in for subsequent mounting.
Precoordinated design is appealing from an economic point of view, as it allows the building owner to make his investment in a solar system when it is economically advantageous. However, success is heavily dependent upon greater standardization of collectors and collector arrays to permit a wide choice of alternatives when ready to proceed.

c. Freestanding Design

In a freestanding design, the collector array is installed on support frames or racks on a flat or slightly sloping surface, such as a graded area next to a building or a flat or shallow slope roof. Dimensional restraints relate to collector orientation and spacing of successive rows, rather than sizes of collectors. Spacing of collector rows should minimize shading, while maximizing the available space and collector orientation. In some regions, special consideration needs to be given to snow/ice build-up around freestanding collectors, and pipes or ducts require insulation against heat loss. In a freestanding design, the projected area of collectors becomes important in design and detailing activities.

d. Retrofit in Existing Buildings or Structures

In a retrofit situation, the solar system should be chosen to complement the existing building orientation, available support surfaces, and the structural system. Retrofit may be accomplished by rack mounting if existing roof or wall surfaces are inappropriate for collector orientation or mounting angle. With all building stock designed in foot-inch dimensions, retrofit installations will have to complement customary structural spacings.

2.4 Mounting Alternatives for Flat Plate Collectors

Mounting alternatives for flat plate collectors can be classified under four types:

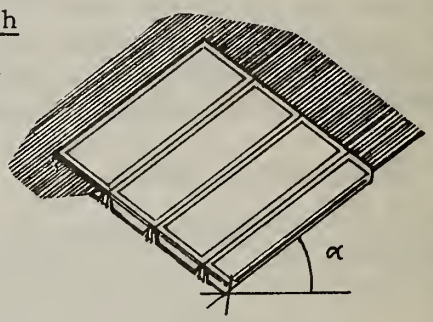
i. integrated into building envelope (roof or wall) and flush
ii. mounted directly to building envelope (roof or wall) and parallel
iii. raised from the building envelope (roof or wall) to preferred mounting angle
iv. frame or rack mounted on flat or near flat surface independent of building.

The matrix below illustrates the most suitable mounting alternatives for various design conditions:

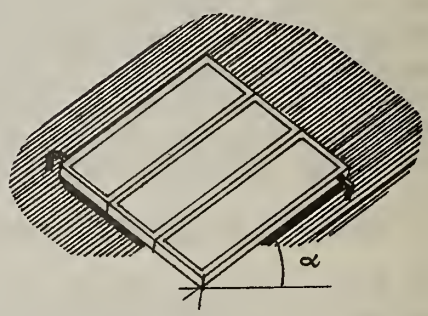
Mounting Alternative	Integrated Design	Precoordinated Design	Freestanding Design	Retrofit
Fully integrated into building envelope	x	-	-	-
Mounted directly on building envelope	x	x	-	x
Raised from building envelope	-	x	-	x
Frame or rack mounted on independent surface	-	-	x	x

The mounting alternatives have been illustrated diagrammatically below:

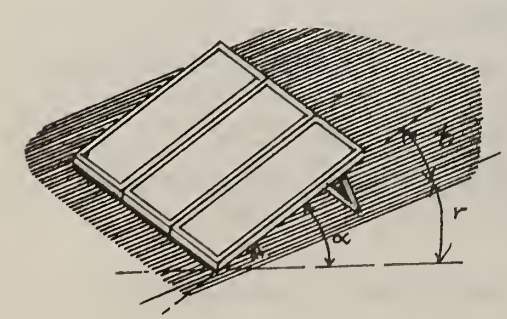
a. Flat plate collectors are <u>fully integrated with the building structure and envelope</u>, and they form a waterproof outer skin in lieu of a roof or other surface.
For best results, the collector plane should face south, and the angle of the plane (α) should be equal to the angle of latitude (L) plus 10°.
All connections and the inlet/outlet locations will be concealed.

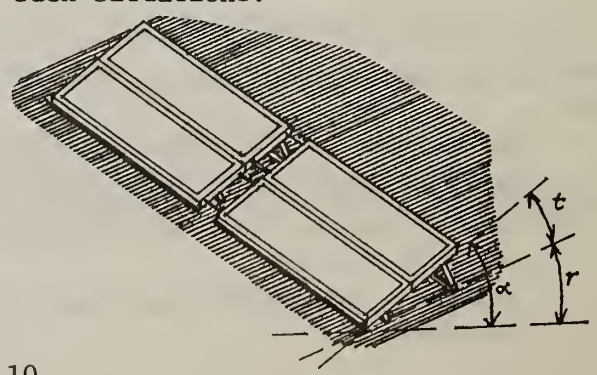


b. Flat plate collectors are mounted <u>directly on the building envelope</u>, generally parallel to it and with a minimal or no air space behind the collector to reduce heat losses. The collector plane should conform to the criteria listed under a.
Inlet and outlet connections will be above the surface. Cover strips, caps, or flashings may be used to close off gaps between the collector and the support surface.

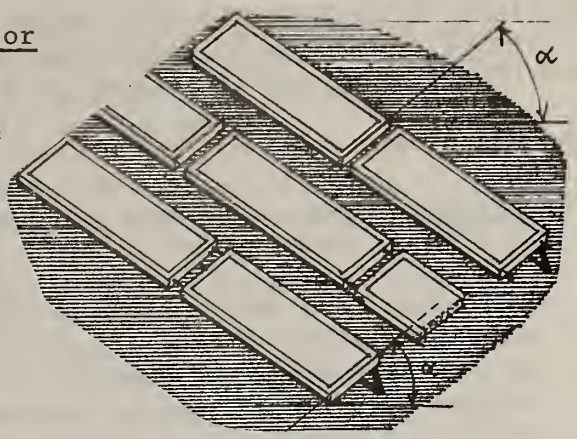


c. Flat plate collectors <u>raised from the building envelope</u> (roof surface) to provide a suitable mounting angle (α) by means of a support frame or rack. The mounting angle, α, is the sum of the roof slope (r) and the tilt angle (t). For structural reasons, it is generally preferable to use collectors with their long edge horizontal in such situations.





d. Flat plate collectors (and concentrating collectors) are mounted on frames or rack supports on an independent flat or near-flat surface, facing true south, and inclined to provide an optimum mounting angle, α. Some systems have adjustable supports which can be changed at predetermined dates to vary the mounting angle for maximum collection of radiant energy. Some concentrating collectors utilize a tracking mechanism to accomplish the same objective. Possibilities exist for the standardization of tracking devices to make them interchangeable.



Shadow angles must be taken into account when collectors are placed in successive rows, to minimize collector shading from other collectors in the installation. Depending upon the characteristics of the system selected, collectors will be installed with the long dimensions either vertical or horizontal.

The support surfaces generally range from horizontal to shallow slopes (flat roofs, paved areas, graded areas, roofs with shallow slopes), or are vertical (building walls or other structural building elements).

2.5 Design of Solar Absorber Units

At this stage of development in the solar industry, there are many different designs for absorber units, the most significant component in determining the collector efficiency. In general, absorber units are made of a conductive metal, painted or coated black, with waterways or ducts for the heat transfer fluid integrated into the total area of exposed absorber.

There are several types of absorber unit, utilizing either parallel flow patterns, serpentine flow patterns, or a combination pattern involving interconnected passageways, such as waffle arrangements through which water or air is distributed.

A number of companies have specialized in the production of patented designs of absorber unit, which are used by various collector manufacturers. The most widely used of such prefabricated, commercially available absorber units are roll-bonded with integral waterways and a single inlet and outlet at each end, made either from copper or aluminum. (See also Section 3.2.4, page 31.)

The dimensions and inlet/outlet positions of the absorber unit have a direct influence on the overall collector size (which is normally 2" to 4" [50 mm to 100 mm] wider and longer than the absorber unit) and the mounting configurations in a collector array.

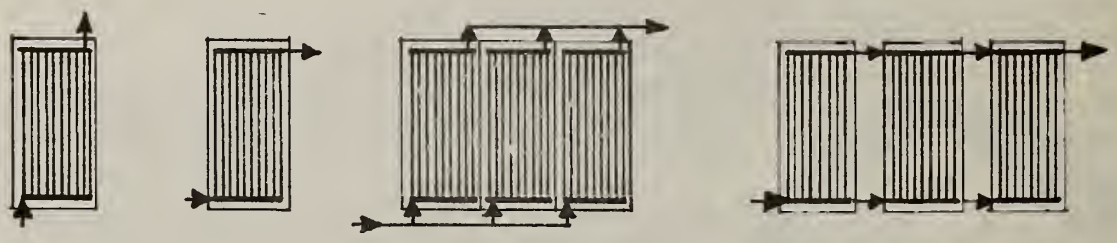
The standardization of absorber units is practicable as the solar industry proceeds towards an industrialized mode of collector production.

2.6 Flow of the Heat Transfer Medium

The flow of the heat transfer medium through the absorber unit in a solar collector determines both the location of connections (inlets and outlets) and the mounting configurations in a collector array.

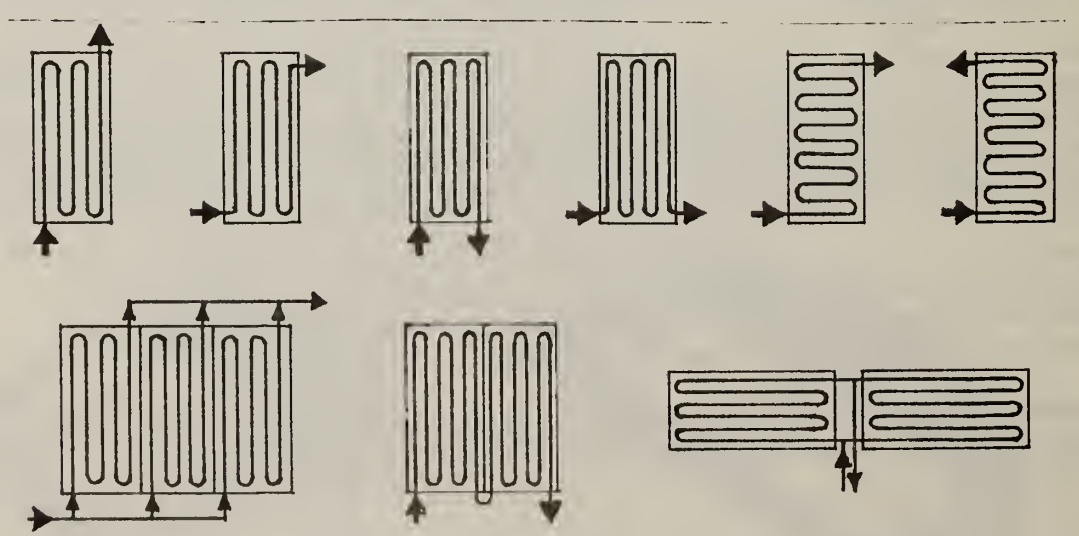
Two broad categories of flow pattern can be distinguished:

a. parallel flow, comprising a series of parallel waterways or ducts, connected by header pipes or ducts at the bottom (inlets) and the top (outlets). Parallel flow occurs in parallel to the long side of the collector, and the collectors are mounted side-by-side in the direction of upward flow. The position of inlet(s) and outlet(s) are generally at the bottom and top edge(s), or at the bottom and top side(s), with either two or four connections per collector, as shown in the diagram below:



The advantage of parallel flow is that flow is relatively uniform so that no panel in an array has excessive temperatures. Some systems have the manifold external to the collector.

b. serpentine flow, representing a continuous path for the heat transfer medium with reverses in direction. The positions of the inlet and outlet can be arranged to suit the geometry of the collector array; for example, they may be on the same side, on the same edge, on opposite sides, or on opposite edges, as shown in the diagram below. A further advantage of serpentine flow is that collectors can be mounted either horizontally or vertically; however, connection in series is limited to two or three panels to maintain efficient flow and to limit temperatures.



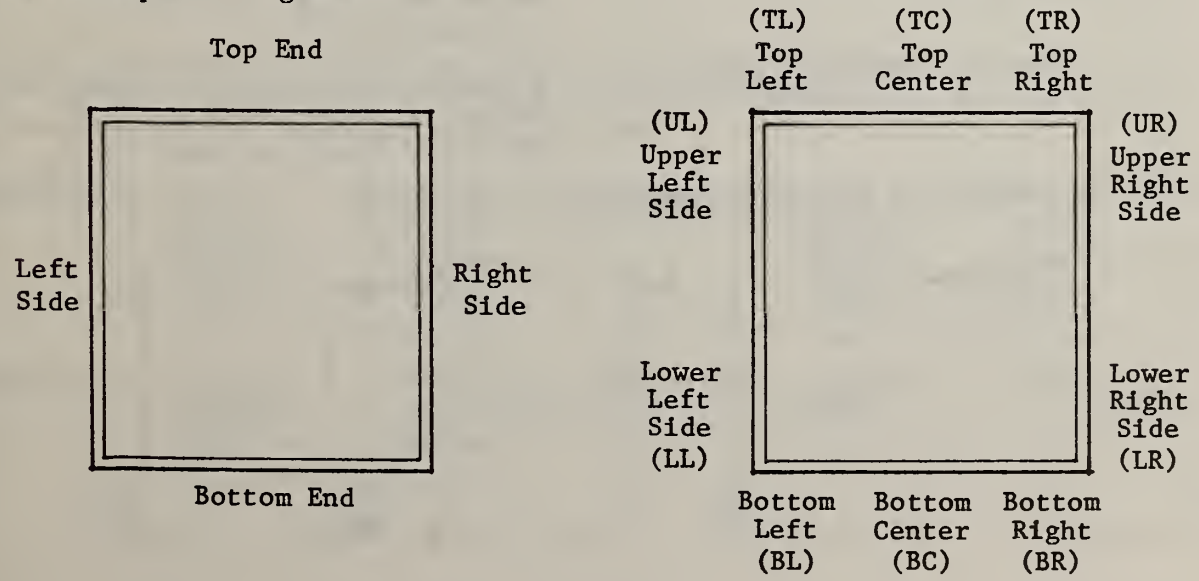
2.7 Location of Collector Inlets and Outlets

The location of the collector inlet(s) and outlet(s) is the principal determinant of configurations and densities with which collectors can be placed in a collector array. To enable consistent descriptions, the following meanings have been assigned to terms used in this report:

Inlet	The passageway, port, or duct, through which the heat transfer medium enters the collector. Its position is designated by the centerline.
Outlet	The passageway, port, or duct, through which the heat transfer medium leaves the collector after passing through the absorber unit. Its position is designated by the centerline.
Side Walls (of Collector)	The surfaces of the collector which form the sides of the enclosure and are generally perpendicular. Side walls are referenced as "right side" and "left side" as viewed from the glazing side of the collector in its installed position.
End Walls (of Collector)	The surfaces of the collector which form the ends of the collector. When installed, end walls form a line parallel to the horizontal plane, and their angle in section is normal to the collector tilt angle. End walls are referenced as "bottom end" and "top end" as viewed from the glazing side of the collector in its installed position.
Back (of Collector)	The rear part of the collector enclosure not exposed to solar radiation and closest to the support surface.

For the purpose of this report, collectors have been grouped according to the location of inlet and outlet pipes or connectors, as measured or stated in manufacturers literature, in liquid collectors. In some instances, more than one configuration can be provided by the manufacturer to suit design or installation requirements. Some collectors can be reversed (turned upside down) to provide alternative inlet/outlet positions.

To enable a comparison of dimensional data, collectors have been grouped in a number of categories with similar inlet/outlet locations. Dimensional data are presented in Appendix 6, according to the code shown below and in the subsequent diagrams:

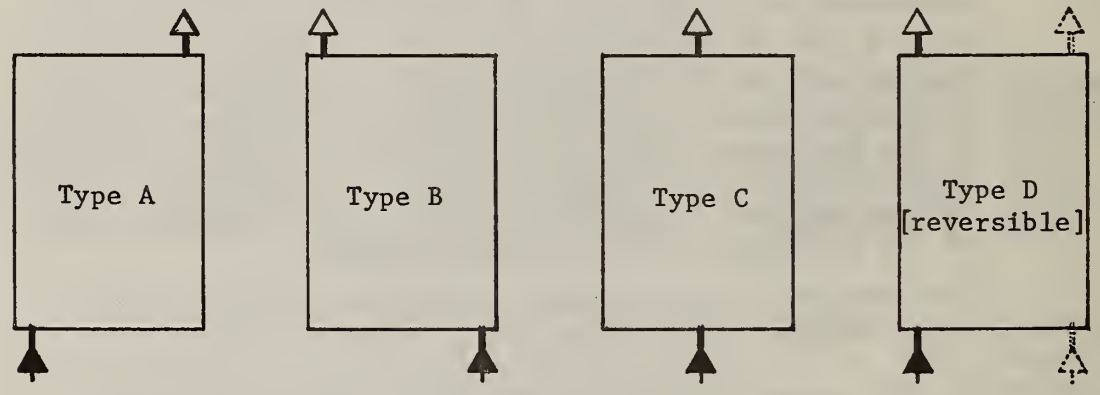


The following categories have been used for dimensional and other comparisons:

Category 1 Inlet and Outlet in End Walls

Type A:	Diagonally Opposite:	Inlet Bottom Left Outlet Top Right
Type B:	Diagonally Opposite:	Inlet Bottom Right Outlet Top Left
Type C:	Directly Opposite:	Inlet Bottom Center Outlet Top Center
Type D:	Directly Opposite:	Inlet Bottom Left (or Right) Outlet Top Left (or Right)

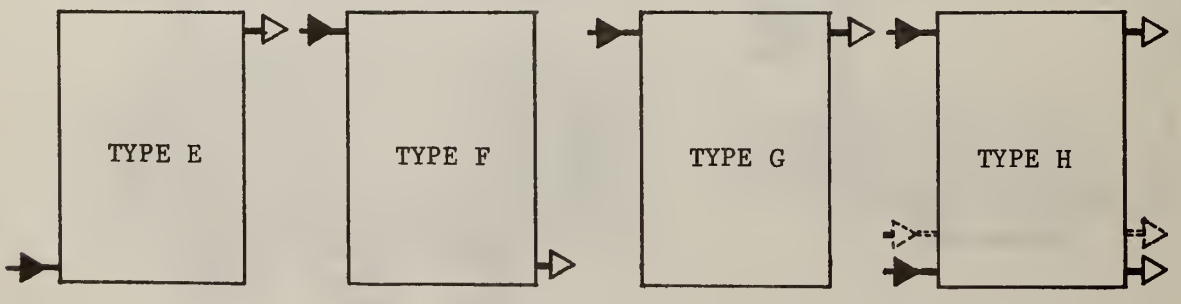
Collectors in Category 1 are shown diagrammatically below:



Category 2 Inlet(s) and Outlet(s) in Side Walls

Type E:	Diagonally Opposite:	Inlet Lower Left Side Outlet Upper Right Side
Type F:	Diagonally Opposite:	Inlet Lower Right Side Outlet Upper Left Side
Type G:	Directly Opposite:	Inlet Upper Left (or Right) Outlet Upper Right (or Left) (or inverted)
Type H:	Directly Opposite:	Inlets on Left Side (or Right) Outlets on Right Side (or Left) Upper and Lower, or Lower only.

Collectors in Category 2 are shown diagrammatically below:



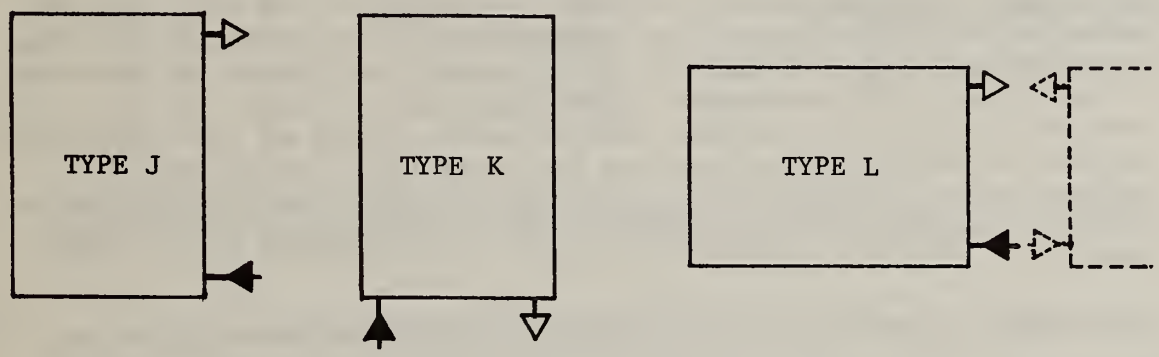
Category 3 Inlet and Outlet at Same Side or End

Type J: Long Side Vertical: Inlet and Outlet on Right Side (or Left Side--reversible)

Type K: Long Side Vertical: Inlet and Outlet at Bottom End (Reversible)

Type L: Long Side Horizontal: Inlet and Outlet at Short Side (Reversible)

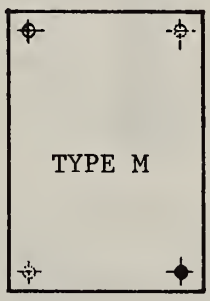
Collectors in Category 3 are shown diagrammatically below:



Category 4 Inlet and Outlet at Back of Collector

Type M: Inlet and Outlet and all Connections are located behind the collector; the position of inlets and outlets varies for different manufacturers.

A typical collector in Category 4 is shown diagrammatically to the right.



Details of centerline locations for inlet and outlet pipes or connections of 88 out of the 141 listed models are given in Appendix 6. The distribution between categories and types is as follows:

Category 1,	Type A	14 models	Category 2,	Type E	3 models
	Type B	20 models		Type F	4 models
	Type C	3 models		Type G	1 model
	Type D	1 model		Type H	21 models
	Total:	38 models		Total:	29 models
Category 3,	Type J	2 models	Category 4,	Type M	5 models
	Type K	2 models			
	Type L	12 models			
	Total:	16 models			

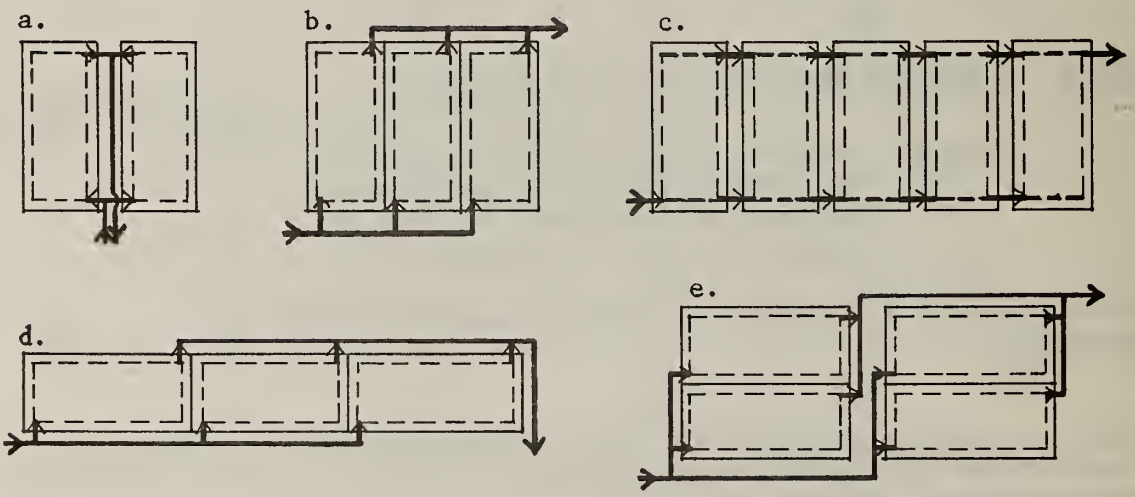
2.8 Collector Arrays

In most solar installations, a number of collectors are combined in the form of an array, in which the flow of the heat transfer medium starts from a cold (normal) supply temperature and is raised successively to a heated state after passing through the collectors. The heated medium is returned to a heat exchanger or storage tank, and the return line is normally located closest to such an exchanger or tank, while the supply line can be placed at the farthest end.

The individual collector, thus, becomes a contributing element in the solar system (installation), much like a cylinder in an engine. The flow of the heat transfer medium may occur with individual collectors connected either "in parallel," or "in series," or in a combination of the two.

2.8.1 Connection in parallel indicates that the supply of the heat transfer medium enters all collectors at approximately equal temperatures, then passes through the absorber unit to be heated, and leaves the collector at the outlet to be connected to the heated return line.
Parallel installations require more extensive piping in the form of headers or manifolds, but have the advantage that a large number of collectors can be joined up in an array to collect large quantities of energy. Limitations are imposed by flow considerations in the return line.

Diagrammatic examples of connection in parallel are shown below:

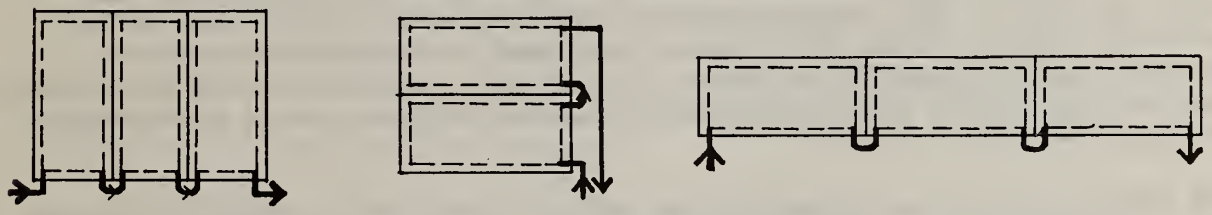


The examples a. and b. can have serpentine or parallel flow absorbers; example c. is for parallel flow absorbers with internal manifolds; and examples d. and e. are for serpentine flow absorbers. Alternative inlet and outlet positions are feasible for example b., and other arrangements or combinations may be designed using collectors of most types.
The greatest density in arrays can be achieved with inlet and outlet locations at the back of the collector, although this may complicate installation and maintenance work.

2.8.2 Connection in series involves flow of the heat transfer medium through successive collectors; therefore, the temperatures in individual collectors will differ as the heat transfer medium is heated progressively.

Connection in series simplifies plumbing and generally reduces the length of exposed piping or ducts and thus heat losses. However, as flow resistance increases with the length of run, connection in series is generally limited to 3 collectors. Connection in series is often suitable in small installations.

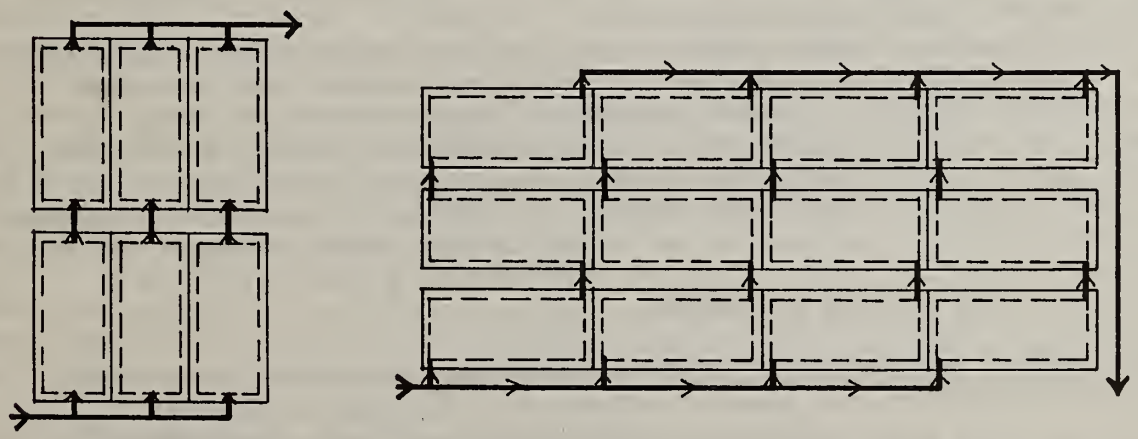
Diagrammatic examples of connection in series are shown below:



Collectors with serpentine flow absorber units lend themselves better to connection in series than do those with parallel flow absorber units.

2.8.3 Connection in combination of parallel and series is practicable in large collector arrays to achieve optimum collector density for minimum runs of exposed piping. The series can run either in a vertical or a horizontal direction, where the array comprises multiple rows of multiple collectors.

Diagrammatic examples of connection combining parallel and series are shown below:



All diagrams are representative of flow patterns only and not to scale. The dotted line indicates the absorber unit which may either have a a parallel or serpentine flow pattern. Absorber units with parallel flow are normally placed so that the heat transfer medium flow upwards as it is heated.

2.9 Spacing of Collectors in an Array

The ideal design of a collector array will have collectors side-by-side and/or edge-to-edge, to present a continuous surface with clearances between collectors just adequate to permit thermal movement and to allow for any irregularities in manufacture. The density of collectors in such an array would approach unity, as the sum of the areas of all individual collectors (ΣA_g) would approximate the overall area of the array (A_A). In practice, clearances are needed between collectors to allow for the connection of inlet(s) and outlet(s). The interconnection of collectors in series or in parallel will necessitate either horizontal clearances (C_h) between the sides of adjacent collectors in a horizontal row, and/or vertical clearances (C_v) between top and bottom edges of sucessive collectors installed one above the other. The amount of space required between collectors varies with individual systems and designs of arrays, but should be kept to a minimum, consistent with performace requirements and maintenance requirements such as the removal of an individual collector without having to dismantle an entire array.

The overall area of a collector plus half the required clearance all around in an array can be considered as the coordinating size of the individual unit (or module). The smaller the required clearances, the easier it will be to waterproof (snowproof) the surface of the array by means of a snap-in flashing, bridging cap, or other patented detailing between collectors. It will also reduce lateral heat loss from collectors in an array.

Since the positions and projections of inlet(s) and outlet(s) are primarily responsible in determining the geometry of a solar collector array, it is appropriate to summarize the clearance requirements likely to be encountered with different inlet/outlet configurations.

a. Inlet/outlet locations at bottom and top make collectors preferable for side-by-side mounting in an array, as minimal horizontal clearances (C_h) are required between collectors.
This arrangement is most useful in single-high arrays where it achieves the highest collector density and reduces heat losses from the sides of collector panels. However, supply and return piping or ducts, or manifolds, will be exposed and require careful insulation to minimize heat losses during the transport of the heat transfer medium.
In double-high or triple-high arrays, the vertical clearance (C_v) between successive rows of collectors may be quite substantial to allow for the interconnection of pipes or ducts; for example, a space of 4" to 8" (100 mm to 200 mm) may be needed.

b. Inlet/outlet locations at the sides require a horizontal clearance (C_h) between collectors, but enable collectors to be mounted adjacent in multiple rows, with a minimal vertical clearance (C_v). Since most collectors have a ratio of 2:1 to 3:1 between the long side and short short side (herein referred to as bottom or top end), inlet and outlet locations at the (long) sides reduce the density in a collector array because a larger total area is required for clearances between collectors.
The space between collectors should be covered in areas with likely snow or ice build up, to prevent heat loss and deterioration.

c. Special couplings for inlet(s) and outlet(s) at the sides have been developed by some manufacturers. One particular system utilizes a special snap-in coupling to connect internal headers and to enable collectors to be placed side-by-side with a minimal clearance between them. This interesting approach provides for much greater density in an array than otherwise possible, and reduced heat loss. However, it may necessitate some additional work if an internal collector has to be removed from an array for repair or replacement.

d. Inlet/outlet location at the same side or end generally indicate that the collector uses a serpentine flow pattern. With a symmetrical collector design, the collector can be inverted for side-by-side connection of two collectors to a single supply line and return line. In the case of inlet/outlet positions at the bottom or top end, high densities can be achieved in an array; however, for connection in series, only three collectors should be interconnected to guarantee efficient flow rates and performance.

e. Inlet/outlet locations at the back of the collector enable arrays to have the greatest density as collectors may be placed end-to-end and side-by-side. This approach is most commonly used in air collectors with inlet and outlet ports at the back. However, unless there is adequate access to pipes, ducts, or connections, difficulties may be encountered with this configuration when servicing or repair is needed. Inlet and outlet locations at the back can be very effective in free-standing installations with frame or rack supports mounted on an independent surface.

2.10 Prefabricated Arrays

The prefabrication of collector arrays under factory conditions has considerable conceptual appeal. In that way, collector assembly onto or into a pre-engineered stiffened frame provides a rigid unit inclusive of all flow pipes or ducts, which may be completely pretested before installation. A prefabricated array would require pre-determined (or pre-located) mounting positions for efficient installation, and only a minimum of on-site rigging and plumbing--as few as just two connections to the supply and return line. A prefabricated array may be fully pre-mounted on a rack or frame with an appropriate mounting angle.

The disadvantages of prefabrication are primarily in greater difficulties with shipping and handling, as special transportation and mechanical lifting are likely to be required to move and install a prefabricated assembly.

Many different configurations are possible for prefabricated arrays and, for large installations, this approach to a solar installation is definitely worth considering.

The attempt to prefabricate arrays may be combined with the fabrication of stamped or pressed collector housings (pans), suitably stiffened, edge profiled and perforated for inlet and outlet openings, utilizing principles adopted in the automotive industry for automobile body sections.

2.11 Dimensional Considerations in Individual Solar Collectors

As there is limited information on dimensions of solar collector arrays, this investigation has concentrated on a study of dimensional aspects of individual solar collectors. Appendixes 1 - 3 list dimensional data for 186 models produced by 153 manufacturers, and includes specified data from manufacturers' technical information as well as measured data from the physical measurement of collectors submitted in the Department of Energy Solar Collector Test Program and collectors evaluated by various testing laboratories.

In the assessment of such data, it became clear that it would be desirable to distinguish between various types of dimensional references to avoid the possibility of confusion in design, detailing, or installation. The following dimensions need to be distinguished:

1. standard (specified) dimensions
2. nominal (designated) dimensions
3. manufacturing dimensions including tolerances
4. actual (measured) dimensions including deviations from standard dimensions
5. coordinating dimensions for the space taken in a collector array
6. projected dimensions

In this section, proposals are made for the identification and referencing of various collector dimensions and measurements. The following symbols are used:

C_h = horizontal clearance between sides of adjacent collectors
C_v = vertical clearance between top and bottom of adjacent collectors
d = diagonal measurement (corner to opposite corner)
D = depth (thickness) of flat plate collector
L = standard (specified) length of collector
L_c = coordinating length of collector module within array $(L + 2\frac{C_v}{2})$
L_l = measured length of collector, left side
L_{max} = maximum manufactured dimension, length
L_{min} = minimum manufactured dimension, length
L_p = projected length of collector on horizontal plane
L_r = measured length of collector, right side
t_l = manufacturing tolerance on length of collector
t_w = manufacturing tolerance on width of collector
W = standard (specified) width of collector
W_b = measured width of collector, bottom end
W_c = coordinating width of collector module within array $(W + 2\frac{C_h}{2})$
W_{max} = maximum manufactured dimension, width
W_{min} = minimum manufactured dimension, width
W_p = projected width of collector on horizontal plane (= W)
W_t = measured width of collector, top end

The various dimensions and their significance are described below and are illustrated diagrammatically and by means of a practical example. The

example chosen for illustrative purposes shows collectors with the width (short dimension) placed horizontally. In some systems, the length (long dimension) is placed horizontally.

2.11.1 Standard (Specified) Dimensions

The standard (or specified) dimensions of a solar collector are width (W), length (L), and depth [or thickness] (D), measured on plan and in section over the furthest projection of the housing, but excluding any projections of pipes, connectors, ducts, or mounting hardware.

Standard dimensions are required for manufacturing and design purposes, as well as for ordering and installation decisions. In practice, standard dimensions may vary marginally within permissible tolerances. Standard dimensions, on their own, are inadequate to determine the overall dimensions of a collector array, since all required clearances for jointing of pipes or ducts, for installation, maintenance or replacement, and for any movement have to be taken into account and added.

Standard (specified) dimensions have been illustrated in Figure 1, and Figure 2 shows a collector array with six collectors (two rows of three collectors each) to illustrate the effect of horizontal clearances (C_h) and vertical clearance (C_v).

Figure 1

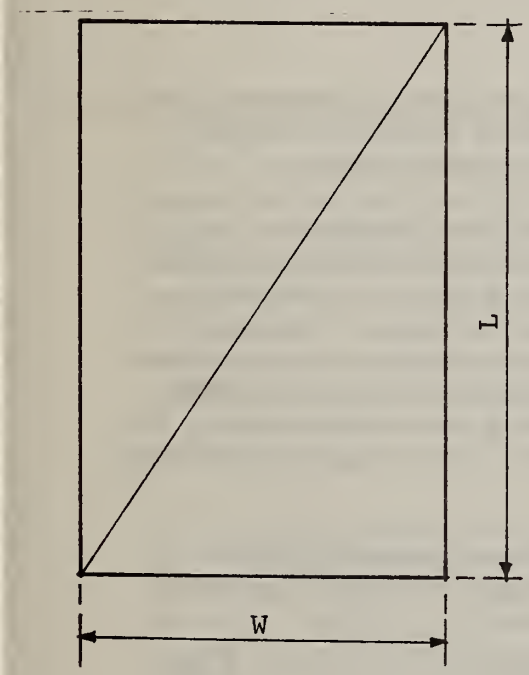
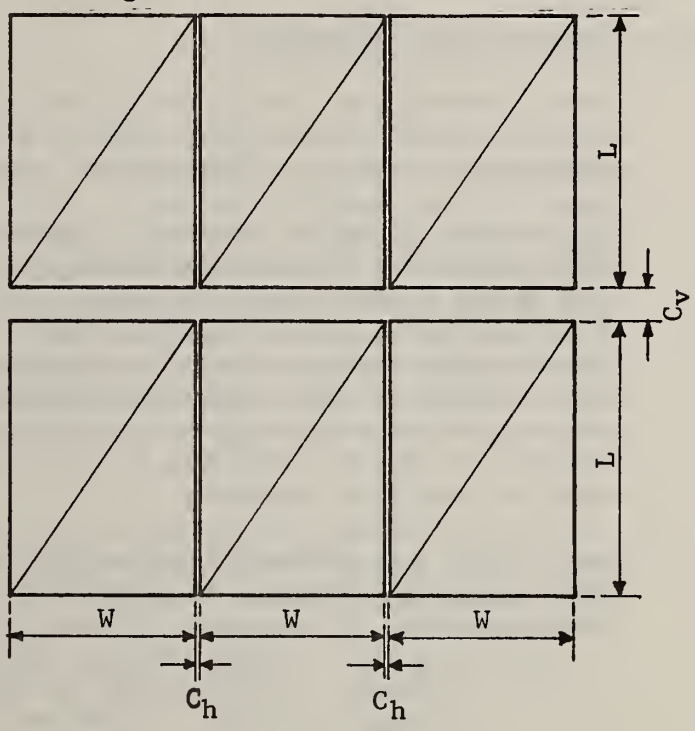


Figure 2



To provide a practical illustration, the following collector dimensions have been assumed:

W	= 47.25"	[1200 mm]
L	= 71.25"	[1810 mm]
C_h	= 0.75"	[19 mm]
C_v	= 8.75"	[222 mm]

Other dimensions will be related to these standard or specified dimensions.

2.11.2 Nominal (Designated) Dimensions

In the past, it has been common practice to use nominal, generally rounded, dimensions to designate size for reference or identification purposes. For example, a flat plate collector with standard dimensions of 47.25" x 71.25" would most probably have been designated in trade information as a "nominal 47" x 71" collector," or as a "nominal 48" x 72" collector," using the nearest whole inch in the description. Alternatively, such a collector might even be described as a "nominal 4' x 6' collector," using the nearest whole foot for general identification purposes. Whereas such rounding provides a convenient numerical designation, it needs to be remembered that "nominal" dimensions exist in name only. Therefore, errors and costly mistakes can be caused when a nominal dimension is used for detailing purposes.

At times, a nominal dimension may coincide with a standard or a coordinating dimensions; however, such designations should never be used as the basis for the design detailing in an array as it will invariably lead to inaccuracies.

It is anticipated that the concept of reference by "nominal dimensions" or "nominal sizes" will be avoided in metric building and design practice.

2.11.3 Manufacturing Dimensions

During manufacture, small deviations from the standard dimensions for a collector will occur or may even be preplanned to allow for thermal expansion or any other dimensional changes after manufacture.

It is common practice to assign limits between which manufacturing dimensions must be held for reasons of accuracy and matching of collectors in an array. The "tolerance (t)" indicates the total amount by which a dimension is allowed to vary. While a tolerance with equal positive and negative deviation is most common, this is not a prerequisite; the positive or negative deviation from the standard dimension may be unequal and, in some circumstances one of them may be zero. For example, it may be desirable to hold the minimum manufacturing dimension equal to standard dimension.

To provide a practical illustration, the following manufacturing dimensions and permissible deviations from standard dimensions have been assumed:

W_{min}	= 47.125"	[1197 mm]	Deviation:	-0.125"	[-3 mm]
W_{max}	= 47.50"	[1206 mm]	Deviation:	+0.25"	[+6 mm]
t_w	= 0.375"	[9 mm]			
L_{min}	= 71.00"	[1803 mm]	Deviation:	-0.25"	[-6 mm]
L_{max}	= 71.50"	[1816 mm]	Deviation:	+0.25"	[+6 mm]
t_l	= 0.50"	[12 mm]			

Collectors with manufacturing dimensions that fall within these limits would be acceptable. Manufacturing dimensions are illustrated in Figure 3.

Figure 3

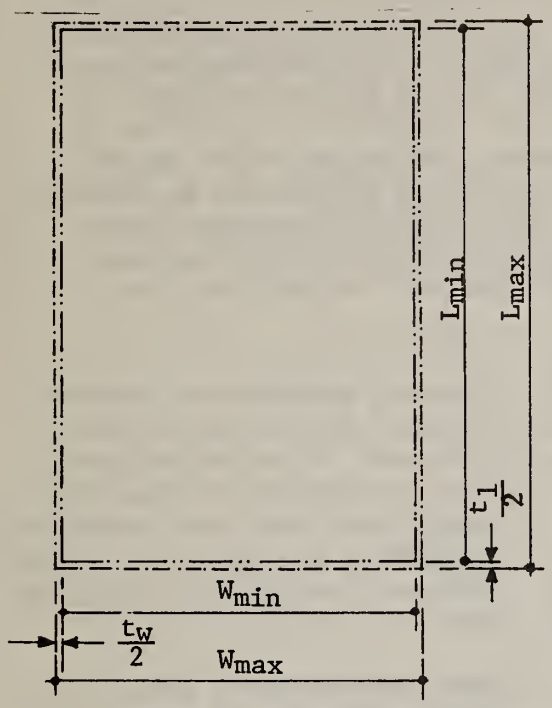
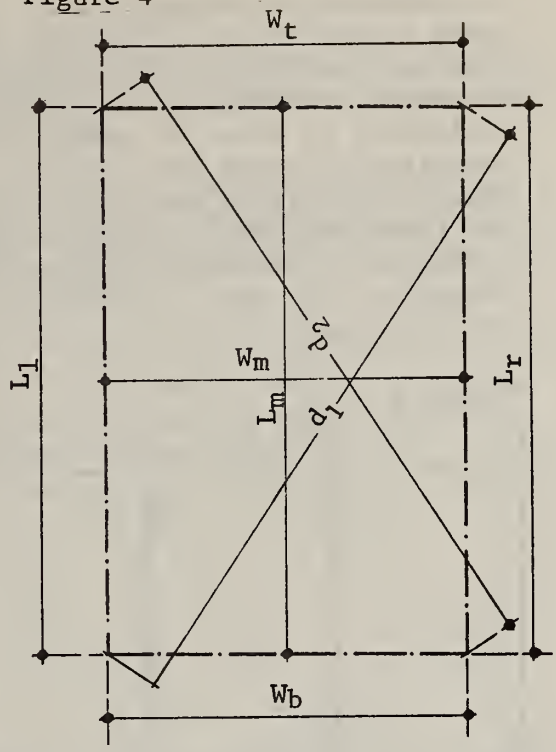


Figure 4



2.11.4 Actual (Measured) Dimensions

Actual, or measured, dimensions are established by precise measurement during production (quality control) or prior to purchase (quality assurance). Normally, measurements would be carried out on all four sides and across the diagonals to establish compliance with limits as well as squareness of the collector. Additional measurements may be made a mid-points of width or length, or for long and narrow collectors at third-points to ascertain whether there are any other irregularities, such as bowing. Twisting or warping measurements may be taken as well by positioning the collector on a flat and level surface and measuring any deviations.

Actual measurements would include: width at bottom end (W_b), width at top end (W_t), width at mid-point (W_m); length at left side (L_l), length at right side (L_r), length at mid-point (L_m); length of diagonals (d_1 and d_2). Depth [thickness] should also be measured at several points around the perimeter, and any other desired points. The principal measurements of actual dimensions are illustrated in Figure 4.

If a collector has been designed for specific standard dimensions, it is desirable to verify general compliance with these dimensions by actual measurement prior to its delivery. All significant deviations are likely to have an impact on the ease of collector installation, and may even have a detrimental impact on collector performance; for example its weather resistance.

Deviations from standard (specified) dimensions are discussed in the next section.

2.11.5 Coordinating Dimensions

The coordinating dimensions of a collector indicate the size of the space needed for an individual collector within a group of collectors, or array, including all necessary clearances. The coordinating space, therefore, is taken to the centerline of joints between adjacent collectors in a row or column, and to the centerline of the pipe or installation space left between successive collectors which are not placed adjacent to each other. Clearances need to include an allowance for irregularities in manufacture and for fitting tolerances when a collector is removed and/or replaced. Sometimes the coordinating dimensions (W_c and L_c) are equal to the nominal designation given to the collector.

Figure 5

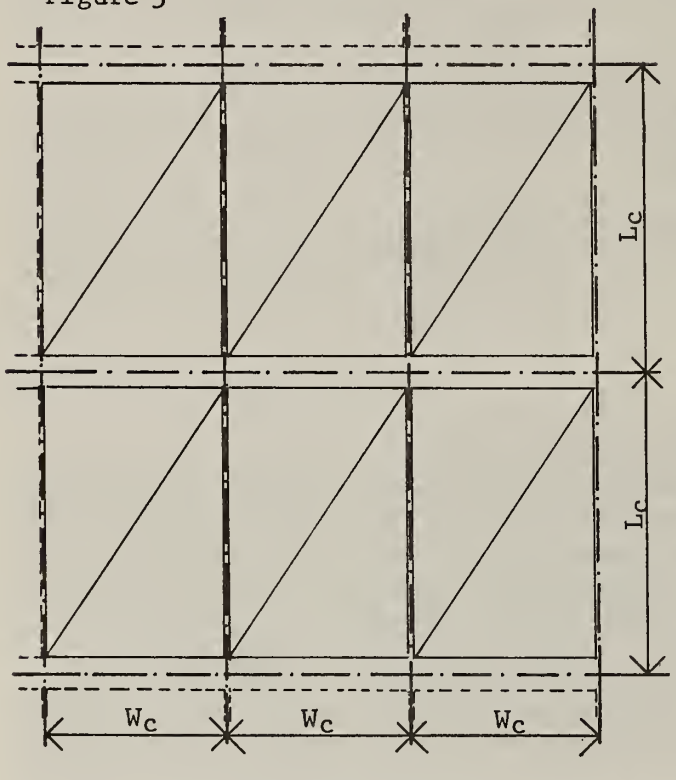


Figure 5 illustrates an array in which only a small joint clearance is needed between side-by-side collectors, but significant pipe and connection clearances are required between tops and bottoms of successive rows.

Some manufacturers refer to the coordinating dimension(s) as the collector "module."

The coordinating dimensions for air collectors are generally closer to the standard dimensions, because collectors have inlets and outlets at the back with placement side-by-side or end-to-end for maximum thermal efficiency and minimum heat loss from in-line air flow through tightly air sealed duct ports.

The coordinating dimensions provide a direct measure of the effective density with which collectors can be installed on a building surface or other support system. To permit proper design and detailing of solar installations, information on coordinating dimensions should be provided in manufacturers' technical literature.

To give a practical illustration of coordinating dimensions, the collector dimensions and clearances from 2.11.1 have been used:

$$W_c = W + (2 \times \frac{C_h}{2}) = 47.25" + (2 \times \frac{0.75"}{2}) = 48.00"$$

$$[1200 \text{ mm} + (2 \times \frac{19 \text{ mm}}{2}) = 1219 \text{ mm}]$$

$$L_c = L + (2 \times \frac{C_v}{2}) = 71.25" + (2 \times \frac{8.75"}{2}) = 80.00"$$

$$[1810 \text{ mm} + (2 \times \frac{222 \text{ mm}}{2}) = 2032 \text{ mm}]$$

2.11.6 Projected Dimensions

In freestanding and supported arrays with multiple rows of collectors, the projected dimensions become significant for design purposes, both for structural calculations and detailing.

Whereas the projected width (W_p) on plan or in section remains the same as the standard (specified) width (W), provided that the top and bottom edges are level, the projected length (L_p) varies with the mounting angle, α, as illustrated in Figure 6.

For example, if the standard collector dimensions shown in 2.11.1 are used (W = 47.25" [1200 mm]; L = 71.25" [1810 mm]), with a collector depth (thickness) D = 3.75" [95 mm], and a mounting angle (α) of 40° to the horizontal, the projected dimensions would be:

Projected width:

$W_p = W = 47.25"$ [1200 mm]

Projected length:

$L_p = (L \times \cos 40) + (D \times \sin 40)$

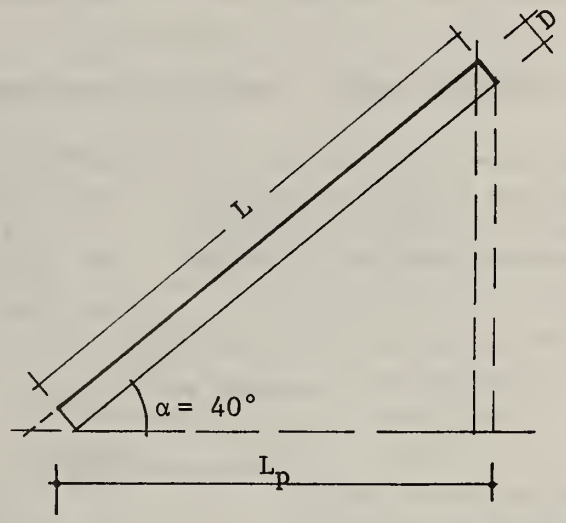
$= (71.25 \times 0.766) + (3.75 \times 0.643)$

$= 54.58" + 2.41"$

$= 56.99"$ (say: 57.0")

= [1448 mm]

Figure 6



2.12 Deviations from Standard Dimensions

In all manufacturing processes, deviations from the target dimensions will occur. If these deviations are kept within established tolerances, the resulting products are quite acceptable. A number of manufacturers of solar collectors provides information on positive and negative deviations that may be expected for width and length of collectors, thus providing the designer and installer with an indication of manufacturing tolerances.

At this stage of development in the solar industry, actual (measured) dimensions of solar collectors are likely to differ somewhat from the targeted sizes, especially for products that are produced in small batches assembled on layout tables or benches. Volume producers with improved procedures for dimensional control during manufacture will generally provide collectors close to the standard (specified) dimensions.

As part of this investigation, deviations of measured dimensions from specified dimensions were investigated for 121 collectors for which both sets of data were available, and the results of this comparison for width,

length, and area is shown in Appendix 5, on pages 124 - 126.

The results of this comparison are interesting, and are shown in abbreviated form in the matrix below:

Type of Flat Plate Collector	Liquid	Air	Special	All Types
Total number in comparison	100	16	5	121

1. Measured width compared with standard width

	Liquid F.P.	Air F.P.	Special	All Types
Measured dimensions equal	24 (24%)	5 (31%)	-	29 (24.0%)
Measured dimensions smaller	26 (26%)	3 (19%)	3 (60%)	32 (26.4%)
Measured dimensions larger	50 (50%)	8 (50%)	2 (40%)	60 (49.6%)
Range -0.125" to +0.25"	66 (66%)	11 (69%)	4 (80%)	81 (66.9%)

2. Measured length compared with standard length

	Liquid F.P.	Air F.P.	Special	All Types
Measured dimensions equal	23 (23%)	2 (12%)	-	25 (20.6%)
Measured dimensions smaller	17 (17%)	3 (19%)	2 (40%)	22 (18.2%)
Measured dimensions larger	60 (60%)	11 (69%)	3 (60%)	74 (61.2%)
Range -0.125" to +0.25"	66 (66%)	11 (69%)	4 (80%)	81 (66.9%)

3. Measured area compared with standard (specified) area

	Liquid F.P.	Air F.P.	Special	All Types
Measured area equal	11 (11%)	2 (12.5%)	-	13 (10.7%)
Measured area smaller	31 (31%)	2 (12.5%)	3 (60%)	36 (29.8%)
Measured area larger	58 (58%)	12 (75%)	2 (40%)	72 (59.5%)
Range -0.1 ft^2 to +0.1 ft^2	46 (46%)	6 (37.5%)	2 (40%)	54 (44.6%)
Range -0.2 ft^2 to +0.2 ft^2	64 (64%)	9 (56%)	3 (60%)	76 (62.8%)

The above data indicate that there is a tendency for actual (measured) collector dimensions to be larger than the standard (specified) dimensions, with 50 percent of measured collector widths larger than specified, and 60 percent of collector lengths larger than specified. If a range of tolerance of 0.375" (-0.125" to +0.25") is accepted as a permissible range for dimensional deviations, then two thirds of all collectors would fall within such a range in terms of both width and length.

A more significant deviation from standard (specified) sizes occurs with collector areas. Only a small percentage of all measured collectors actually conform to the standard (specified) area. The majority of collectors--nearly sixty percent--demonstrate that the measured area is larger than the standard (specified) area. Since gross area (A_g) of the collector is used in the calculation of collector performance, actual (measured) gross area may provide different results from standard (specified) gross area.

The establishment of guidelines for permissible deviations is recommended.

PART 3: PREFERRED DIMENSIONS AND SIZES IN BUILDINGS, SOLAR SYSTEMS, AND SYSTEM COMPONENTS

3.1 Preferred Dimensions in Building Design

North American building technology has traditionally been based on dimensional preferences that are whole multiples of the foot (12 inches) and the inch. With the advent of national standards for modular coordination after World War II, the customary building module of 4 inches has become a further determinant in building geometry. Preferred dimensions based on whole multiples of these units of size are evident in the selection on centerline-to-centerline spacings of framing members in building, as well as related "coordinated" building products.

In the framing of small buildings, extensive use is made of members spaced at preferred intervals of 12 inches, 16 inches, and 24 inches for horizontal and vertical members, and 16 inches, 24 inches, 36 inches, and 48 inches for roof framing members or trusses. Panel materials, such as plywood, complement these dimensions; for example, the most common plywood size is 48" x 96" (4' x 8'). Larger spacings are used for laminated roof beams and purlins, such as 72 inches (6 feet), 96 inches (8 feet), 120 inches (10 feet), and 144 inches (12 feet); the secondary members are employed to interconnect the primary beams at intervals that make it possible to use panel materials effectively, such as 24 inches, 32 inches, or 48 inches center to center. Structural framing members of steel or concrete are used in commercial and industrial buildings, and these may be spaced even further apart; however, they are normally connected by secondary members (beams, purlins, joists) at closer centers. In reinforced concrete structures, the roof system may be a structural concrete slab, or a precast section, suitably waterproofed by external membranes. In such instances, preferred structural dimensions are generally selected by the designer in response to functional requirements, one of which might be the support of a solar installation.

Structural preferred dimensions have some bearing on the design and integration of a solar installation.

a. Secure mounting of external components of a solar system is achieved when the support frame(s), mounting rack(s), brackets, angles, or other mounting hardware are connected to structural framing members, rather than merely to the roof deck or membrane, or the external envelope.

b. All penetrations of the external envelope, such as pipes or ductwork, must remain clear of structural members.

c. Integrated systems need to be supported by structural members but fit in between them if they are to form part of a flush external surface.

d. Structural members must be designed for any additional point loads or distributed loads anticipated as a result of a solar installation. Members in existing buildings should be checked to see whether they can support additional loads imposed by a retrofit system.

Taken together, these design factors impose some limitations on the location of collector mountings and the positioning of pipes or ducts associated with the heat transfer system.

3.2 Preferred Dimensions and Sizes for Collector Components

Apart from the absorber unit, which is the functional core of a solar collector, other components in a flat plate collector are principally designed to protect the absorber against external influences of weather, impact, or other forces, and to minimize heat loss from the absorber unit by suitably insulating it. The collector housing also provides the mounting positions and hardware for installation of the collector as part of an array on a suitable support frame or surface.

Since building components have provided most of the readily available materials for the production of solar collectors, their dimensions have had considerable impact on the sizing of solar collectors in the United States. Structural and insulating components of solar collectors include: complete collector housings, side members (rails) or extrusions, back panels, cover plates, insulating materials, absorber components, sealants, hardware and accessories, in addition to normally available commercial pipes, connectors, or ducts for the heat transfer medium.

3.2.1 Collector Housings

The collector housing--also referred to as collector box, collector case, collector enclosure, collector frame, or collector pan by different manufacturers--may be made of a variety of materials.

There are two broad types: one-piece housings, manufactured in a single unit; and, composite housings, made from a number of constituent components, generally consisting of a frame for sides, ends, and transverse stiffening with a backing plate.

One-piece housings are either molded plastic units or pressed metal pans with suitable stiffening and edge profiling to facilitate assembly of the collector, fastening of the cover plate, and integration into an array.

Composite housings are more common at this stage of development of the solar industry. Most of them use extruded or pressed metal (side) frames, with a metal back panel. A number of systems utilize lumber side sections and a plywood or other rigid board back panel. There is no specific preference in evidence, as panel thicknesses vary--and therefore side sections--and panel sizes exhibit great variety. A number of air collectors utilize a 48" x 96" (4' x 8') plywood back panel, and this seems to be the principal determinant of collector size.

Housings for integral mounting between structural members are generally designed to a 22" width for use between roof members spaced at 24" centers.

3.2.2 Collector Insulation

Nearly all solar collectors have an insulating material placed at the sides and the back of the collector housing to minimize heat losses from the absorber unit. The most common insulating materials are: fiberglass or mineral wool batts, which are available in commercial sizes of 24" (23.5"), 34", 36", 46" and 48" widths to complement collector dimensions; board insulation in closed cell materials (foams), available in various widths and lengths (11.5", 23", and 46" for polyurethane foam, 47" for polyvinyl chloride and isocyanurate foams); and, foamed in-situ materials.

Back insulation generally utilizes a greater thickness than side insulation. For most effective insulation, it is desirable to have a continuous insulating material without joints, as any joint separation would create a loss of thermal efficiency by creating a direct path for absorber heat loss. The most effective insulation sizes, therefore, are those that complement the collector dimensions and require neither cutting to waste, nor jointing. From this standpoint, good results can be achieved with foamed-in-situ insulation. It should be noted, however, that several foamed insulations may experience significant shrinkage (with a commensurate loss in R-value) and outgassing when exposed to temperatures likely to occur in solar collectors. All insulating material must withstand breakdown at elevated temperatures, such as might occur under stagnation conditions.

3.2.3 Collector Cover Plates

Nearly all flat plate collectors for long term solar installations have a cover plate or cover plates to seal the collector housing against intrusion of dust or moisture, and to protect the absorber against external conditions (such as snow or hail) which could damage it. Another function of the cover plate is to provide a barrier against convective heat loss from the absorber.

To perform effectively in hail or snow conditions, and under expected wind loading conditions (both positive and negative pressure), the cover plate needs to be strong and shatterproof. Many solar collector manufacturers have designed their units to take maximum advantage of commercially available glazing materials and optimum spans for such materials under anticipated loading conditions.

Cover plates may either be a single or double glazed unit, covering the entire collector aperture, or multiple plates supported by a number of glazing bars.

Among the units that cover the entire collector aperture without any intermediate supports, the most common material is the 34" x 76" (864 mm x 1930 mm) tempered glass cover plate which is a direct adaptation of the of the 34" x 76" patio door glass, an inexpensive piece of toughened glass which is produced by a number of manufacturers in large quantities. This piece of glass cannot be cut without a loss in physical properties and, therefore, it becomes a dimensional forcing function in the solar collector. The 34" x 76" tempered glass cover plate has had quite an influence on the sizing of flat plate collectors and is one of the reasons for the predominance of the nominal 36" x 78" (3' x 6.5') collector.

As sheet or plate glass is one of the heaviest components in a solar collector--a single sheet of 3/16" thick glass weighs approximately 2.8 lb/ft^2, or approximately 50 lb for a 34" x 76" cover plate, many collector manufacturers have experimented with alternative and lighter cover plate materials. These include:

PVF (polyvinylfluoride)	0.004" (0.01 mm)	0.028 lb/ft^2
Tedlar	0.001" (0.025 mm)	0.007 lb/ft^2
FRP (fiber reinf. polyester)	0.040" (1.0 mm)	0.30 lb/ft^2
Acrylic	0.125" (3.2 mm)	0.75 lb/ft^2
Polycarbonate	0.125" (3.2 mm)	0.77 lb/ft^2
Water White Temp. Glass	0.125" (3.2 mm)	1.63 lb/ft^2

The ligter materials require intermediate supports to obtain workable spans for the collector cover plate. Double glazed units are optional in many of the systems listed. Some manufacturers use an inner skin of polyterephthalate (mylar) or TFE fluorocarbon (teflon) to provide an additional barrier to heat loss from the absorber plate.

During the change to metric dimensions, some rationalization of sheet glass thicknesses is likely, and this could affect the maximum spans for different solar collector cover plates. A comparison is shown below of thicknesses and dimensional tolerances for typical cover plates of sheet glass, or plate and float glass (heat strengthened or fully tempered).

Glass produced to U.S. customary units is specified in Federal Specifications DD-G-1403B, "Glass, Plate (Float), Sheet, Figured, and Spandrel (Heat Strengthened and Fully Tempered)" and DD-G-451D, "Glass, Float or Plate, Sheet, Figured (Flat, For Glazing, Mirrors, and Other Uses)." The latter document also contains metric designations and tolerances. These glass thicknesses are compared to Canadian Government Specifications Board standards 12-GP-2M, "Standard for: Glass, Sheet, Flat, Clear" and, 12-GP-3M, "Standard for: Glass, Polished Plate or Float, Flat, Clear."

DD-G-1403B Thickness (inches)	Sheet Glass (inches) min.	Sheet Glass (inches) max.	Sheet Glass (mm)* min.	Sheet Glass (mm)* max.	Plate or Float Glass (inches) min.	Plate or Float Glass (inches) max.	Plate or Float Glass (mm)* min.	Plate or Float Glass (mm)* max.
1/8"	0.115	0.134	(2.92)	(3.40)	0.094	0.156	(2.38)	(3.97)
5/32"	0.145	0.165	(3.68)	(4.19)	0.125	0.188	(3.18)	(4.76)
3/16"	0.182	0.205	(4.62)	(5.21)	0.156	0.219	(3.97)	(5.56)
13/64"	---	---	--	--	0.172	0.234	(5.16)	(5.95)
7/32"	0.205	0.230	(5.21)	(5.84)	0.187	0.250	(4.76)	(6.35)
1/4"	0.236	0.264	(5.99)	(6.71)	0.219	0.281	(5.56)	(7.14)

DD-G-451D Dimensional Tolerance for Rectangular Shapes of Transparent Primary Glass (Float, Plate or Sheet)

Thickness Designation Customary	Metric	Tolerance (inches) min.	Tolerance (inches) max.	Tolerance (mm) min.	Tolerance (mm) max.
Double-1/8"	3.0 mm	0.115	0.134	2.92	3.40
5/32"	4.0 mm	0.149	0.165	3.78	4.19
3/16"	5.0 mm	0.180	0.199	4.57	5.05
7/32"	5.5 mm	0.200	0.218	5.08	5.54
1/4"	6.0 mm	0.219	0.244	5.56	6.20

CGSB 12-GP-2M Thickness (mm)	Sheet Glass, Flat (mm) min.	Sheet Glass, Flat (mm) max.	Sheet Glass, Flat (inches)* min.	Sheet Glass, Flat (inches)* max.	CGSB 12-GP-3M (mm) min.	CGSB 12-GP-3M (mm) max.	Plate or Float (inches)* min.	Plate or Float (inches)* max.
3	2.7	3.3	0.106	0.130	2.5	3.5	0.098	0.138
4	3.6	4.4	0.142	0.173	3.5	4.5	0.138	0.177
5	4.6	5.4	0.181	0.213	4.5	5.5	0.177	0.217
6	5.6	6.4	0.220	0.252	5.5	6.5	0.217	0.256

* Soft conversion only, based on data provided

3.2.4 The Absorber Unit

The absorber represents the functional core of the collector and, generally, is designed for optimum energy collection vis-avis cost of production. The most common absorber plate materials are copper, copper/aluminum combinations, aluminum, and steel. Liquid collectors include pipes or flow channels for the heat transfer medium in addition to a collector plate or fins, while air collectors feature various plate materials, or fin configurations over or through which an air stream is passed.

There is a great variety of designs for absorber units, and little dimensional standardization is evident. However, a number of manufacturers have concentrated on the production of standard absorber units rather than complete collectors, and, to some extent, such standard (stock) products become a forcing function in the overall sizing of the collector.

A widely used absorber unit, produced in copper or aluminum, is a pressed and roll-bonded unit with integral tubes and headers shaped during manufacture. Produced from 0.040" [1 mm] thick copper plate or 0.060" [1.5 mm] thick aliminum plate, the units have transverse connecting tubes to balance liquid flow within the absorber, and a single inlet and outlet.
Of the 134 liquid collectors, for which information on the absorber unit was available, a total of 19.4 percent utilize the commercial product(s) of a single manufacturer--19 units [14.2%] in copper, and 7 units [5.2%] in aluminum.
Of the dominant absorber sizes, the following have a distinct impact on the overall collector geometry: 22" x 94"; 34" x 76"; 34" x 94"; and, 34" x 96".

Designs that utilize tube and plate arrangements, with copper tubes bonded to copper or aluminum plates, both available sheet materials sizes and pipe lengths become a forcing function, if waste of materials is to be avoided. One manufacturer developed a collector design, in which efficient use of the standard length of copper tubing (20'-0") was a forcing function--the most economical cutting of such tube is into three lengths of 80" each.

Since the size of the collector housing generally exceeds the size of the absorber plate by between 1" and 4", depending on the amount of side insulation used, a strong reciprocal relationship exists between collector sizes and absorber plate sizes. A number of manufacturers utilize a 34" x 76" (864 mm x 1930 mm) absorber unit, thus further reinforcing the dimensional dependency already established by the tempered glass cover plate.

3.2.5 Overall Collector Size Factors

In the overall sizing of collectors, a trade-off occurs between economical use of materials and economic performance. The most influential factor in relation to sizing is that, generally, the larger the collector, the fewer will be the number of connections in an array of given gross area and, thus, a reduction in installation time should be possible. However, a larger size, especially with a glass cover plate, will be heavier and, therefore, may complicate transportation, handling, and installation, as well as requiring a stronger (and heavier) support structure. The optimum size represents a trade-off between these conditions. Ideally, sizes should be related to logical steps in demand, so that an array can be sized accordingly with two, three, four, or more collectors.

Architectural considerations may determine preferred arrangements in a solar collector array, but functional limitations determine the number of collectors that can be connected in series or in parallel. Horizontal arrays--that is, vertical collectors joined in series or in parallel--tend to be favored in technical information provided by manufacturers. Collectors with serpentine flow patterns can be installed either in a horizontal or vertical configuration. Drain-down and venting requirements need to be taken into account in the detailed design of an array and the choice of collectors.

3.3 Collector Shape Factor

Solar flat plate collectors can be produced in a variety of rectangular shapes for the same gross collector area (A_g). However, the ratio of transparent frontal area (A_a) to gross area (A_g) will vary with shape for the same frame width, as will the length of periphery (P = 2 x (W+L)); both of which have some effect on collector performance. Whereas the transparent frontal area is a factor in the determination of thermal performance, the peripheral length influences peripheral heat loss and absorber shading with varying solar positions and angles of incidence.

For functional reasons, a square which represents an optimal shape factor is deficient in terms of span ratios for cover plate materials. A long, narrow collector can utilize a thinner cover plate--thus saving weight--but has more peripheral area, thus using more materials and allowing greater lateral heat loss.

The impact of shape factor is illustrated in Tables 3.3.1 and 3.3.2, in U.S. customary units and metric units, respectively. For the purpose of this study, a gross collector area of 24 ft^2, or 2.16 m^2, has been assumed, with a frame width of 1", or 25 mm, all round as such a width is reasonable representative of existing products. To simplify the analysis, only those dimensions that are multiples of 2", or 50 mm, have been included, except in the case of an assumed square collector. A peripheral length factor (f_p) is shown, based on the ratio of peripheral length (P) to the minimum peripheral length. Also shown is an effective area ratio (r), representing the ratio of transparent frontal area to gross area (A_a/A_g)

Table 3.3.1 (U.S. customary units) Assumed Sizes [for illustrative purposes]

Overall Dimensions (W·L) for 24 ft^2 Collector (inches)	[feet]	Peripheral Length (P) (inches)	Factor f_p	Aperture Dimensions (inches)	Aperture Area (A_a) (ft^2)	Effective Area Ratio (r)
18" x 192"	[1'6" x 16']	420"	1.786	16" x 190"	21.111	0.8796
24" x 144"	[2' x 12']	336"	1.429	22" x 142"	21.694	0.9039
32" x 108"	[2'8" x 9']	280"	1.191	30" x 106"	22.083	0.9201
36" x 96"	[3' x 8']	264"	1.123	34" x 94"	22.194	0.9248
48" x 72"	[4' x 6']	240"	1.021	46" x 70"	22.361	0.9317
54" x 64"	[4'6" x 5'4"]	236"	1.004	52" x 62"	22.388	0.9329
58.78" sq.	[4'10$^{25}/_{32}$" sq.]	235.15"	1.000	56.78" sq.	22.395 max.	0.9331

Factors f_p and r can also be interpreted as percentages: for example, f_p = 1.786 indicates that the peripheral length is 78.6% greater than the minimum; r = 0.8796 indicates that A_a is 87.96% of A_g.

3.3.2 (Metric [SI] Units) Assumed Metric Sizes [for illustrative purposes]

Overall Dimensions (W·L) for 2.16 m^2 Collector (mm)	Peripheral Length (P) (mm)	Factor f_p	Aperture Dimensions (mm)	Aperture Area (A_a) (m^2)	Effective Area Ratio (r)
450 mm x 4800 mm	10 300	1.786	400 x 4750	1.900	0.8796
600 mm x 3600 mm	8 400	1.429	550 x 3550	1.952	0.9039
800 mm x 2700 mm	7 000	1.191	750 x 2650	1.988	0.9201
900 mm x 2400 mm	6 600	1.123	850 x 2350	1.998	0.9248
1200 mm x 1800 mm	6 000	1.021	1150 x 1750	2.012	0.9317
1350 mm x 1600 mm	5 900	1.004	1300 x 1550	2.015	0.9329
1470 mm square	5 880	1.000	1420 sq.	2.016 max.	0.9331

3.4 Mounting Positions for Collectors and Mounting Hardware

Solar flat plate collectors now in production do not exhibit any preferred system of mounting or standardized mounting hardware. Most manufacturers provide some form of mounting instructions with their collectors, and quite a few systems come with optional mounting kits that allow for different installation configurations and mounting angles. Fixing positions cover a variety of locations on the collector periphery or frame, using either brackets or a mounting flange fixed to the collector, or preformed (or pre-threaded) apertures on the collector frame.

Mounting positions need to relate to the spacing of structural support members or systems (racks or frames). In a collector array, the spacing of structural support members should have a direct relationship to collector width and/or length.

Mounting positions and mounting alternatives might be the subject of a separate investigation, as there seems to be considerable scope for variety reduction and standardization.

3.5 Penetrations Through the Roof or Building Envelope

To connect the solar collection system to the thermal storage system, any pipes or ducts for the transport of the heat transfer medium generally have to pass through the building envelope. It is important that the supply line (inlet) to the collector and the return line (outlet) from the collector are located in such a way that pipes or ducts remain clear of structural members in the roof system or support system. Any penetrations need to be suitably water and weather proofed, and yet flexible enough to allow for any thermal movement in ducts, pipes, support frames or collectors.

Penetrations for air ducts are normally larger than for pipes used with liquid heat transfer mediums, and therefore more critical with respect to location in a roof. Ducts are often located behind the collector housing for protection, so that proper matching during installation is important.

3.6 Industry Preferences for Flat Plate Collector Sizes

Dimensions of solar flat plate collectors can be analyzed in two categories: listed (specified) dimensions and actual (measured) dimensions. A comparison of the differences between listed and measured dimensions indicates that the measured dimensions, generally, are slightly larger than the listed ones. For example, of the 14 liquid and special (liquid) flat plate collectors in this investigation listed as 48" x 96", 9 had measured sizes and, in each case, these were slightly larger than the listed (specified) sizes. Therefore, while the 48" x 96" size appears to be an industry-preferred collector size, the actual dimensions are subject to a positive deviation. This indicates the need for dimensional tolerances in relation to listed sizes.

In the evaluation of data for the 149 liquid and special flat plate collectors and the 37 air flat plate collectors, this slight discrepancy has had to be taken into account. It is shown diagrammatically in the scale drawings for both liquid and air flat plate collectors (Figures 3.6.1 and 3.6.2), where listed (specified) dimensions are indicated by broken lines and measured (actual) dimensions are indicated by solid lines. The figures clearly show that preferred widths and lengths for collectors occur in bands around 24", 36" and 48" width, and 78", 96", and 120" in length. The five principal clusters for liquid collectors have been enlarged in Details A, B, C, D, and E, and the two principal clusters for air collectors in Details F and G.

Both figures show distinct clusters of preferred sizes around 36" x 78", 48" x 96", and 36" x 96" [915 mm x 1980 mm, 1220 mm x 2440 mm, and 915 mm x 2440 mm] thus demonstrating a trend in industry preferences.

The interesting aspect is that these sizes focus on a limited number of widths and lengths, which should simplify the design of suitable support systems and accessories to serve different types of collectors; however, the study has not introduced a further distinction between collectors for horizontal use (the long side parallel to the line of the horizon) and vertical use (the long side normal to the line of the horizon).

In the change to metric dimensions, preferred widths and lengths will differ somewhat, and might become 900 mm x 2000 mm or 1000 mm x 2000 mm to replace the 36" x 78" preference, 1200 mm x 2400 mm or 1200 mm x 2500 mm to replace the 48" x 96" preference, and 900 mm x 2400 mm or 1000 mm x 2500 mm to replace the 36" x 96" preference. All these dimensions are modular dimensions, that is, whole multiples of the 100 mm module. Whereas 2400 mm is a preferred dimension in building, 2500 mm is likely to be a preferred dimension in mechanical engineering applications. Some guidance is available on preferred sizes of flat metal products in the American National Standard ANSI B32.3-1977, "Preferred Metric Sizes for Flat Metal Products," which lists the following metric preferred widths (Table 2): 600 mm, 800 mm, 1000 mm, and 1200 mm; and metric preferred lengths (Table 3): 2000 mm, 2500 mm, 3000 mm, 3500 mm, 4000 mm, 4500 mm, 5000 mm, and 6000 mm, in the range of sizes covered by solar flat plate collectors.

A detailed assessment of the implication of metric sizes cannot be made until the flat metal products industry converts to a predominantly metric operation, which is anticipated to occur after 1983. New metric product sizes for sheet metal will affect both collector housings and absorber plates.

Figure 3.6.1

LIQUID FLAT PLATE COLLECTORS
(INCLUDING SPECIAL TYPES)

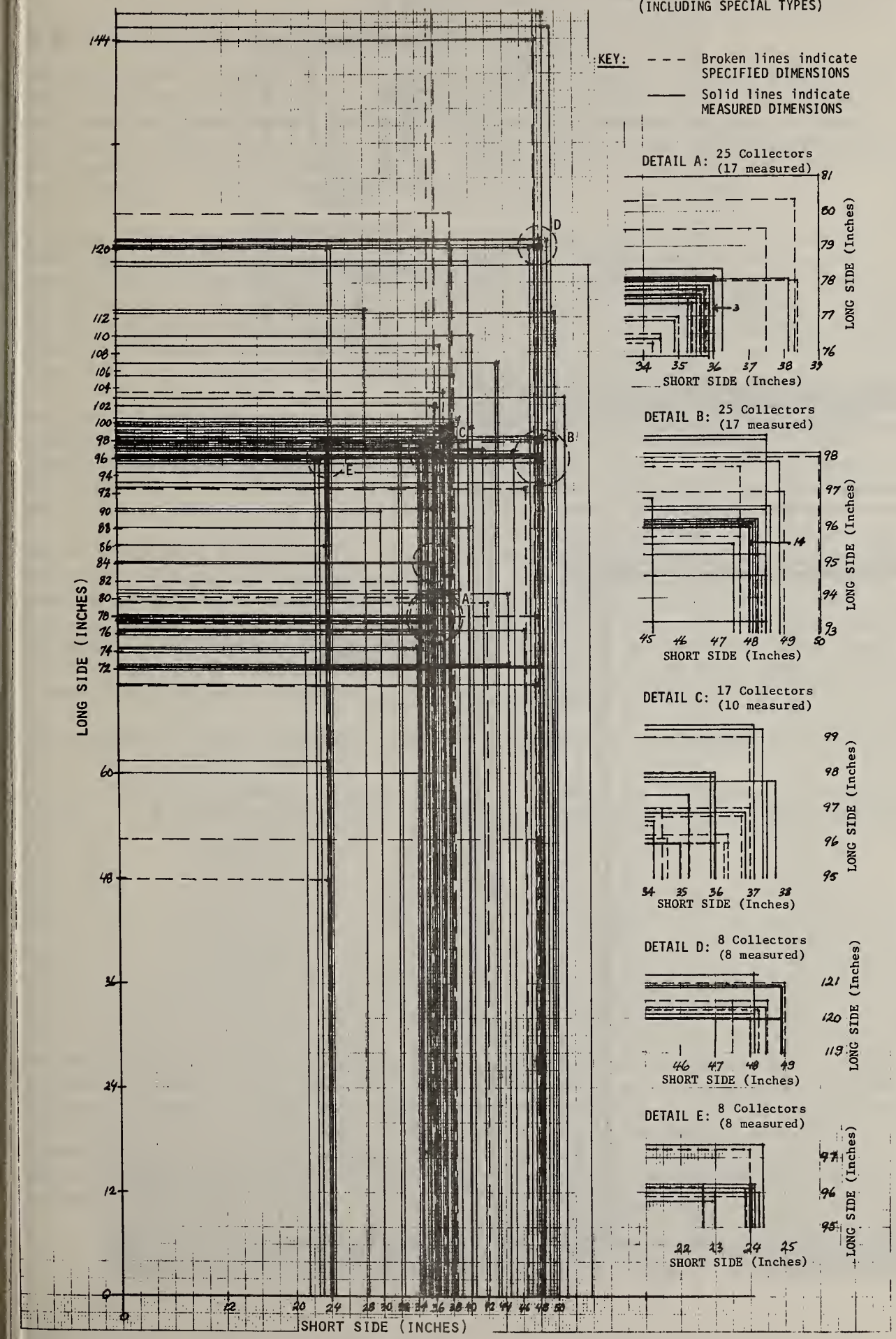
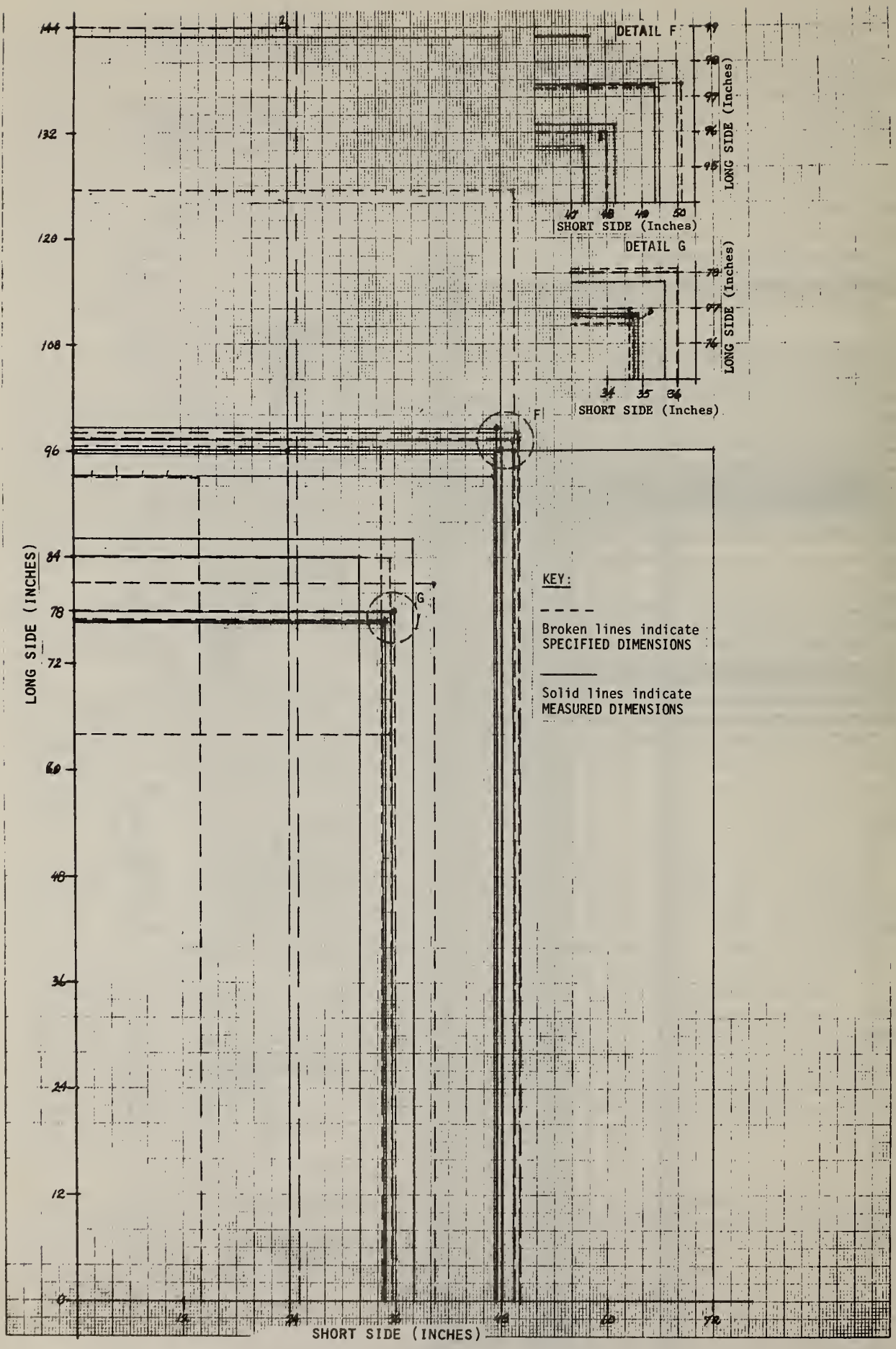


Figure 3.6.2

AIR FLAT PLATE COLLECTORS



3.7 Storage Tanks for Solar Hot Water and Preferred Sizes

Storage tanks for domestic or process (solar) hot water or space heating are made from steel with internal linings of glass or ceramic material, copper, or fiberglass reinforced plastics for larger non-pressurized units. Where the heat transfer medium is a liquid other than water, special precautions may need to be taken to avoid any potential contamination of the potable water supply. In such instances, a heat exchanger is utilized.

Storage tanks are fabricated with or without a heat exchanger, and most of them have an auxiliary element for preheating or supplementary heating of water. The sizing of solar water storage tanks should be related to the total collector area, the expected flow rates for the heat transfer medium, and the demand for hot water (quantity and temperature). For design purposes, various ratios of storage tank size to collector area are suggested, generally ranging from 1.25 to 2.0 gallons per square foot [50 to 80 L/m^2].

Residential type storage tanks are relatively expensive per unit of volume stored, but they are generally maintenance free for long periods. Larger size storage tanks include: non-pressurized steel tanks, fiberglass tanks, and pressurized steel tanks. These tanks vary with different manufacturers and range in volume from 250 gallons [946 L] to 4000 gallons [15 140 L].

There has been a considerable amount of standardization in the sizing of small hot water heaters and storage tanks, based on capacity (liquid volume) expressed in gallons. Manufacturers of storage tanks, with or without integral heat exchangers and/or electrical back-up elements, all offer a similar range of products in volume steps between 30 gallons [114 L] and 120 gallons [454 L], based on an incremental series 30 + 10 + 12 + 14 + 16 + 18 + 20, which can be transcribed mathematically as $y = x^2 + 9x + 30$ in the range $x = 0$ to $x = 6$.

This series of sizes, together with metric equivalents and possible rounding of values is shown below:

Formula	Customary Designation	Soft Conversion	Rounding to nearest 10 L	Rounding to ISO R-10 Preference
[x = 0]	30 gallons	113.6 L	110 L	125 L
[x = 1]	40 gallons	151.4 L	150 L	160 L
[x = 2]	52 gallons	196.8 L	200 L	200 L
[x = 3]	66 gallons	249.8 L	250 L	250 L
[x = 4]	82 gallons	310.4 L	310 L	315 L
[x = 5]	100 gallons	378.6 L	380 L	400 L
[x = 6]	120 gallons	454.2 L	450 L	500 L

Rounding existing sizes to metric sizes provides close approximations to the preferred number series ISO R-10, which features a regular geometric interval between successive sizes; each tank being approximately 25 percent larger than the preceding one. The change to metric units could become the vehicle for future rationalization of sizes based on geometric increments in volume, in which 3 tank sizes (52, 66, and 82 gallons) remain unaltered, but smaller and larger tanks are increased.

An interesting feature of the existing series is that combinations of the same storage tank size and of adjacent sizes lead to intermediate steps for combined capacities, as shown below:

Basic (One-Tank) Capacity	Combined Capacity of Two Tanks	Stored Volume (in gallons)
30 gallons		30
40 gallons		40
52 gallons		52
	30 + 30 gallons	60
66 gallons		66
	40 + 30 gallons	70
	40 + 40 gallons	80
82 gallons		82
	52 + 40 gallons	92
100 gallons		100
	52 + 52 gallons	104
	66 + 52 gallons	118
120 gallons		120
	66 + 66 gallons	132

While a single-tank installation is cheaper, the combination of sizes provides the designer with some flexibility, and permits the addition of a second tank (with or without heating element) in existing systems.

Solar/electric water heaters (storage tanks) are manufactured by a variety of major national and regional producers, generally in glass-lined or stone-lined steel. Manufacturers include:

American Appliance Mfg. Corp.	Santa Monica	California	Glass-lined
A.O. Smith Corporation	Kankakee	Illinois	Glass-lined
W.L. Jackson Manuf. Co., Inc.	Chattanooga	Tennessee	Glass-lined
Lochinvar Water Heater Corp.	Nashville	Tennessee	Glass-lined
Mor-Flo Industries, Inc.	Cleveland	Ohio	Glass-lined
Solar Energy Systems, Inc.	Cherry Hill	New Jersey	Glass-lined
Rheem Water Heater Division	Chicago	Illinois	Glass-lined
Ford Products Corporation	Valley Cottage	New York	Stone-lined
Vaughn Tank Corporation	Salisbury	Massachusetts	Stone-lined

This listing is not exhaustive, but representative of the industry.

Larger storage tanks for commercial installations come in a variety of shapes (rectangular, cylindrical; horizontal or vertical shapes) and materials. Their capacities do not follow a standard series, but include increments such as 250 gallons, 300 gallons, 350 gallons, 500 gallons, 750 gallons, 1000 gallons, 1250 gallons, 1500 gallons, 2000 gallons, 3000 gallons, and 4000 gallons. Some manufacturers provide other sizes for pressurized or non-pressurized tanks.

The development of a standard series of preferred capacities for such storage tanks would assist the industry to produce a smaller variety of competitive models, and facilitate system design and installation. Any such series might be developed using metric preferred increments in liters, for example 1000 L (264 gallons), 1500 L (396 gallons), 2000 L (528 gallons), 3000 L (792 gallons) 4000 L (1057 gallons), 5000 L (1321 gallons), 7500 L (1981 gallons), 10 000 L (2642 gallons), 15 000 L (3963 gallons), and 20 000 L (5283 gallons).

PART 4: SUMMARY AND RECOMMENDATIONS FOR FURTHER WORK

4.1 Summary of Findings

In the study of dimensional considerations in solar installations, it soon became evident that this subject had received only limited attention in the solar industry and that it was not considered a subject of major importance. However, after discussions with solar energy experts, manufacturer's representatives, and system designers the merit of greater standardization in the solar industry was generally acknowledged, including dimensional standardization. It was agreed by most experts that, in order to survive and grow, the sector of the solar industry engaged in the production and use of systems based on flat plate collectors will need to reduce costs and further develop the performance characteristics of its products, especially, in the face of assertions that the economics of such systems generally do not compare favorably with conventional heating and/or cooling systems. Many experts also agreed that some degree of standardization would be a way to improve the industry, although there was little direct analysis on the most suitable areas and why. The idea of greater integration of collectors with the building fabric was regarded as a positive step by some; others saw the trend towards system improvement in the manufacture, transportation and installation of entire "gangs" of collectors or arrays rather than individual collectors as the most promising avenue. Finally, most experts agreed that it would be difficult to standardize a highly fragmented, developing industry from outside other than through selective use of purchasing power which might preclude some of the established manufacturers.

This study does not attempt to set any preferred sizes--it simply lists and collates sizes of collectors and storage tanks in current use in the U.S. market and identifies certain preferences that might become the basis for industry standardization. Inasmuch as no "weighting" of results for the differences in size of individual manufacturers or the production quantity of individual collectors has been introduced, the data are not representative of the actual number of collectors of different sizes in production or use; rather, they represent a picture of where manufacturers of all types and sizes have arrived at this stage of development. For historical reasons, the sizes of smaller storage tanks for liquid heat transfer mediums has already been standardized, with the result that the customer can select from a variety of interchangeable units of the same size.

Further research will be required to determine preferred sizes for collectors and collector components that result in the most logical use of materials and other resources. Ideally, any such sizes should be compatible with the emerging preferences in a future metric industrial environment. Properly, such research is a task of the industry which has just as much vested interest in its further development as has the consumer or bulk purchaser. It appears that, at this stage, many manufacturers are somewhat flexible with regard to product sizing, as is evidenced by the offer of special sizes for bulk orders. The optimum collector size will be an elusive target, but there could be a number of functionally and economically attractive preferred sizes, which would accommodate the production skills of nearly all manufacturers.

During the study it became quite evident that considerable scope exists for the standardization of solar system and collector descriptions, the use of units in such descriptions, and the clear distinction between different sizes for specification, production, and coordination. Further work is recommended in these areas.

4.2 Preferred Sizes and Standardization

The study of dimensional data for solar systems and, especially, solar flat plate collectors marketed or installed in 1978 has indicated that there is no dominant "industry rationale" for the preferred sizing of units, except for solar hot water tanks in the range 30 - 120 gallons, which is a direct adaptation of earlier hot water tank sizes.

Collector sizes exhibit an "individual" rather than "collective" rationale, although some forcing functions can be distinguished. This is reminiscent of the stage of development of the building materials industry prior to the advent of modular coordination in the post-World War II era, or the automotive industry prior to assembly lines and mass production. A large number of individual producers developed and fabricated products to their own preferred sizes.

The industry-wide standardization of sizes provides incentives and stimulus for all parties engaged in the manufacture, distribution, installation or use of solar energy products. It is expected that the development of preferred sizes for solar flat plate collectors, for example, through decisions taken by the industry and incentives provided by the public sector, would accomplish the following desirable objectives:

1. Faciliate the functional comparison of units or systems of the same size, thus acting as a direct stimulus for functional efficiency improvement by direct competition between manufacturers.
2. Permit the dimensional interchangeability of systems, thus providing a potential client with a greater variety of choices.
3. Simplify the design process by allowing precoordination for a solar system at the design stage without being "locked into" a particular system. This would include the simplification of structural computations as well.
4. Enable the preparation of standard design guides and details for solar installations of various configurations, to ensure optimum density and minimal shading from other collectors in an installation.
5. Rationalize the design and construction of support frames, racks, or other structures, including their hardware, and allow their integration with the structural members of a building for maximum efficiency and minimum cost.
6. Simplify plumbing and installation activity through standardization of connections and penetrations through the weathertight building envelope.
7. Encourage efficient production with minimal waste of materials and labor through longer production runs of preferred size products.
8. Encourage mass production of major collector components, such as housings, frames, absorber plates, cover plates, etc., in the knowledge that they would fit with prototypes of individual manufacturers. Such mass production, rather than batch production, would stabilize prices, provide greater certainty of supply, and lead to functional performance improvements.

However, standardization is not practicable without an appreciation of these and other benefits, and a definite preference for standard products among customers. The Federal Government could provide the incentive for standardization, by letting the industry establish a limited number of preferences for use in the Solar Federal Buildings Program.

4.3 Recommendations for Follow-up and Future Projects

Since this investigation of "dimensional considerations in solar installations" started without any real precedent, the study proceeded initially on an ad-hoc basis and gradually locked into a framework after successive refinements in the presentation and analysis of material. In the process it became evident that the collection of up-to-date (1980) data on solar flat plate collectors and solar hot water tanks could provide additional information, especially if it is conducted within a predetermined framework and coupled with computerized evaluation. This would require a follow-up with system and collector manufacturers, including a "weighting factor" for actual quantity of production.

The first recommendation, therefore, is to share the information of this study with the solar industry and to engage the industry in the process of dimensional and size investigation with the object of establishing "collective" preferences for the 1980's.

While metrication still appears to be some time away, the metals industry is already in the process of change, and the construction industry has advanced in its planning activities, forecasting an M-Day in 1985. Increasing attention, therefore, will need to be given to the transition from one set of measurement preferences to another, and the industry needs to be alerted to consider the potential metric impact in new product planning.

One of the difficulties in this investigation has been the absence of national standards to assist in the description of solar systems and components. This has resulted in a great variety of terms for the same or similar end purpose, a variety of measurement units for the specification of dimensions and/or performance, and haphazard dimensional descriptions.

The second recommendation, therefore, is to initiate and/or support the development of a number of descriptive standards for the solar industry:

a. A national standard glossary of terms, suitably illustrated, to provide the basis for consistent description of solar components

b. A national standard for the use of metric (SI) units in solar energy applications, or a companion standard listing both U.S. customary and metric (SI) units of measurement, to provide the basis for the consistent use of measurement units.

c. A national standard for the specification and measurement of solar collectors, providing clear guidance on the use of dimensions and methods for measurement verification of collector dimensions, including limits and tolerances.

In addition, it would be useful to develop a standard procedure for the classification of collector categories and types--as attempted in this document--to distinguish different configurations of flow pattern and connection.

Finally, extensive public funds have been used (directly and indirectly) to assist in the development of a viable solar industry. It is suggested that a seminar or conference be held on "Opportunities for Standardization in Solar Systems and Components," with a view to obtaining feedback from all segments of the solar industry (manufacturers, distributors, installers, designers, specifiers, purchasers, and users) on the desirability of dimensional and other standardization efforts, including the use of public funds to support the development of standard sizes, or the use of large scale procurement of such preferred sizes.

PART 5: TECHNICAL DATA AND THEIR EVALUATION

5.1 Technical Data for Flat Plate Collectors

Information on dimensional aspects of flat plate solar collectors was gathered for the following number and types of collectors:

1. Liquid Flat Plate	114 manufacturers	141 models
2. Air Flat Plate	31 manufacturers	37 models
3. Various Special Types	8 manufacturers	8 models
Total:	153 manufacturers	186 models

This information was obtained from public sources, including manufacturers' technical literature, product catalogs and drawings, industry journals, test reports from the Florida Solar Energy Center and other testing laboratories, Residential Solar Data Center reports, submissions to the Department of Energy Solar Collector Test Program, and Department of Housing and Urban Development reports. Special mention must be made of the valuable data obtained from collector measurement and sampling reports carried out by the Solar Energy Research and Education Foundation (SEREF) as part of the DoE Collector Test Program.

In presenting the selected technical data dealing with dimensional factors it is acknowledged that manufacturers' drawings and production techniques are adjusted from time to time, that some manufacturers have introduced new or modified models since the data were collected, and that some manufacturers have amalgamated or withdrawn from production. The information contained in this report represents measurement data relative to the period 1978/1979, and is analyzed to indicate trends rather than an exact state of the art.

In the presentation and analysis of dimensional information, a distinction has been made between "listed" and "measured" collector panel dimensions. Listed dimensions are dimensions specified in technical literature or shown on manufacturer's drawings; measured dimensions are dimensions established by actual physical measurement of one or more collector samples.

In the analysis of dimensional aspects, the following measurement information has been used:

System Type	Listed and Measured	Listed Only	Measured Only	Total Models
1. Liquid	100	38	3	141
2. Air	16	20	1	37
3. Special	5	2	1	8
Total	121	60	5	186
% of Total	65.0	32.3	2.7	100.0

5.2 Selection and Presentation of Dimensional Data for Flat Plate Collectors

Appendixes 1 to 3 of this Report contain comprehensive dimensional listings of flat plate solar collectors. The format for these listings was evolved over a period of time after testing various configurations for the presentation of such data. An initial objective to have a full page set aside for each collector model was discarded as it would have increased the bulk of the report unnecessarily. The data collected would have lent themselves to computerized listing and evaluation procedures which, while outside the scope of this project, might be considered in any future work.

In the presentation of dimensional data, it was decided to group collector manufacturers by states in which their headquarters are located, rather than alphabetically, as this will permit an additional analysis of regional dimensional or design factors. There are some distinct regional patterns of collector design and dimensioning, in addition to the segmentation into air collectors for colder regions--as they require no freeze protection--and liquid collectors for warmer regions. Where a manufacturer's headquarters and manufacturing facilities are known to be located in different states, the headquarters location has been used as the key identifier in this listing. Table 5.2 (page 44) provides a summary of the distribution by states of various collector system manufacturers.

Appendix 1 contains data for 141 liquid flat plate collectors produced by 114 manufacturers. California and Florida account for approximately 40% of both manufacturers and models listed.

Appendix 2 contains data for 37 air flat plate collectors produced by 32 manufacturers. This listing includes a number of site-built systems and is not as detailed as the information for liquid flat plate systems. The listing clearly shows that manufacturers in colder states predominate.

Appendix 3 contains data for 8 special types of flat plate collecting systems produced by 8 manufacturers. These have been selected as relevant in the context of the investigation.

In gathering data on flat plate collector systems, additional manufacturers or suppliers were identified; however, this information was either not in a form that could be utilized in this report or else received too late to be included in the analysis.

It is important to note that this investigation of dimensional considera- does not distinguish between large volume collector manufacturers and systems and those produced in limited quantities or on a one-of-a-kind basis. For statistical purposes it would be desirable to use a "modifying factor" which provides for appropriate weighting of results according to actual or estimated market share. Such factors might be used in any future analysis of the data contained in this report, whether this be done collectively or selectively, with or without the introduction of additional manufacturers or models.

Table 5.2

COLLECTOR MODELS AND MANUFACTURERS COVERED IN DIMENSIONAL INVESTIGATION:

State Where Headquarters of Manufacturer Are Located	Liquid Flat Plate Number of		Air Flat Plate Number of		Special Types Number of	
	Manuf.	Models	Manuf.	Models	Manuf.	Models
Alabama	4	7				
Arizona	1	1				
California	25	28			1	1
Colorado	5	5	4	5	1	1
Connecticut	3	3	1	2	1	1
Delaware	1	1				
Florida	22	28			2	2
Georgia	2	2				
Hawaii	4	4				
Illinois	1	2	1	1		
Indiana	1	3				
Iowa	1	1	1	1		
Kansas			1	1		
Kentucky			1	1		
Louisiana	1	1				
Maine	2	2	1	1		
Maryland	1	1				
Massachusetts	5	6	2	2		
Michigan	1	1	1	1		
Minnesota	2	2	1	1		
Missouri			1	1		
Nebraska			1	1		
New Hampshire			2	2		
New Jersey	4	4				
New York	6	12	1	1		
North Carolina	1	1	1	1		
Ohio	4	6	3	4	1	1
Oregon	1	1				
Pennsylvania	4	6	3	4	1	1
Rhode Island	1	1				
South Dakota			1	1		
Tennessee	1	1				
Texas	6	8			1	1
Vermont	1	1				
Virginia	3	4				
Wisconsin			4	5		
Washington	1	1				
Total	114	141	31	37	8	8

In the tabulation of collector characteristics, the first item (A) lists the collector model name and/or number used by the manufacturer. Collectors which were included in the DoE Collector Test Program carry an additional identification number in parentheses on the right hand side.

The next twelve items (B to M) have been chosen to represent the significant measurement characteristics of flat plate collectors, and they are shown in both U.S. customary units and metric (SI) equivalents in brackets. Converted values are given to the nearest millimeter (mm) without any substantial rounding. The items included in the listing of characteristics were chosen after a number of trial listings featuring different measurement aspects. An earlier version included a listing of collector insulation type(s) and thickness(es), but was deleted as insulation sizes do not represent a forcing function of collector face dimensions, although they influence the collector thickness.

A brief commentary on each of the items included in the listing of measurement characteristics is given below:

B. Listed Panel Dimensions (Width, Length, Depth [Thickness])

Listed panel dimensions are taken from published technical data, such as trade literature, solar catalogs, manufacturers' specifications, and, where available, manufacturers' drawings. In general, the most accurate dimensions are found in manufacturers' drawings; the least accurate dimensional in advertising material.

Listed dimensions are generally shown in inches, rather than feet and inches, with either common fractions to the nearest 1/8" or 1/16", or with decimal fractions (common fractions expressed as decimals or stated to the nearest 0.1" or 0.05"). Only a small percentage of all measurement statements includes dimensional tolerances--primarily in drawings--such as: 47" ± 1/16"; 74-5/8" ± 1/8"; 37-1/4" (+1/16", -0").

A large percentage of listed panel dimensions is given a "nominal" dimensions expressed to the nearest foot or inch, such as: 4' x 8'; 48" x 96"; 3' x 6.5'; 36" x 78". The actual [measured] dimensions may either be larger or smaller.

Only a few manufacturers include metric (SI) units in their product dimensions. Generally, such expressions are confined to the statement of metric equivalents in parentheses, not always in preferred units or correct unit symbols. One manufacturer, however, has chosen to show metric units first in technical specifications and literature, stating size as 1.2 meters x 2.4 meters (4' x 8') even though these dimensions differ by 1.6 percent and are not interchangeable. Actual measurements show that the collector size to be 48.1" [1222 mm] x 96.125" [2442 mm].

C. Measured Panel Dimensions (Width, Length, Depth [Thickness])

Measured panel dimensions were obtained from two principal sources: the measured solar collector configuration drawings prepared by SEREF field engineers during solar collector selection visits in the DoE Solar Collector Test Program, and the solar collector test reports prepared by the Florida Solar Energy Center [FSEC]. Altogether, measured dimensional information is available for two thirds (67%) of all collectors listed in Appendixes 1 to 3.

C. [Continued]

Measurements carried out by SEREF field engineers are generally taken to the nearest 1/16", but are expressed in decimal fractions of inches. For example, 48-3/16" would be shown as 48.1875" or, occasionally, as 48.19".

All measurements taken at FSEC are expressed in metric units, although in the summary information sheet "descriptions" measurements are also shown in decimalized feet. Linear dimensions shown in meters are given to three decimal places, therefore yielding an accuracy to the nearest millimeter.

Where collectors in this investigation have been measured both by SEREF personnel and FSEC, the measurements by SEREF have been used in item C.

D. Gross Collector Area [A_g]

The total or gross collector area is established by simple multiplication of measured collector width and length for models where measured data are available, and by multiplication of listed dimensions where no measured data are available. Gross area, designated A_g in ASHRAE Standard 93-77, is expressed in square feet to two places of decimals, with a metric equivalent in square meters shown in brackets.

There is evidence of some discrepancy between gross area of collectors listed by manufacturers and gross area derived by measurement, due to the fact that measured dimensions tend to exceed listed dimensions.

E. Coordinating Dimensions (Width, Length)

Where collectors are used in an array of multiple modules in parallel, in series, or in combinations of parallel and series flow, the effective space occupied by the individual collector determines the collector density in the array. In building terminology, the centerline dimensions between horizontally or vertically adjacent collectors are termed "coordinating dimensions." Such coordinating dimensions are important in relation to building geometry, mounting configurations and techniques, and design detailing for collector systems and buildings. Collectors designed for close spacing have more effective coordinating dimensions than collectors that require substantial horizontal and/or vertical clearances for connections.

Only a small percentage of manufacturers provides coordinating dimensions for solar collectors, generally expressed as centerline distances between modules.

F. Cover Plate Material(s) and Dimensions

Solar collectors utilize a variety of cover plate materials, ranging from rigid flat glass in single or double glazed configurations, through flat or profiled acrylic cover plates, polycarbonates, and other plastic cover plate materials, to thin sheets and films supported by transverse support strips.

Materials requirements for cover plates can be related directly to net spans across and along the collector face--the wider the span, the more rapidly increases the need for stronger and, generally, heavier materials.

F. [Continued]

Item F has been included to permit an analysis of "forcing functions" between cover plate materials and collector sizes; especially, as there is a widespread belief that the 34" x 76" sheet of tempered glass used traditionally for patio doors became an early determinant of collector size due to its widespread availability and relatively low cost.

The freedom of cover plate design increases with 36" x 96" and 48" x 96" plastic sheeting materials.

G. Net Aperture Dimensions

The net aperture dimensions represent the clear distance, in section, between framing elements and/or gaskets that is spanned by the cover plate material. In FSEC collector test reports, these dimensions are termed transparent frontal dimensions.

Net aperture dimensions are shown in inches with decimal fractions and metric equivalents in millimeters.

H. Net Aperture Area [A_a]

The net aperture area (referred to as transparent frontal area in ASHRAE Standard 93-77) is an important component of collector performance calculations. Therefore, it is generally included in manufacturers' technical information, although the aperture areas given in such data do not always coincide with data in this report.

Net aperture area is expressed in square feet to two places of decimals, with a metric equivalent in square meters shown in brackets.

I. Aperture as % of Gross Area

This percentage, or ratio, of aperture area to gross area provides some indication of solar collector efficiency as thermal performance equations include both A_a and A_g. The vast majority of percentages falls between 87% and 93%. Percentage figures are based on actual measured information, wherever available.

J. Absorber Material(s) and Size (Width, Length)

The size of the absorber unit in a solar collector represents another "forcing function" in terms of dimensional considerations. The collector enclosure will always have to be larger than the absorber plate, to allow for peripheral insulation and edge clearances, and in many units the width of the absorber plate is 2 inches [50 mm] smaller than the width of the enclosure.

While the design of absorber units varies widely, with a predominant use of copper waterways and copper or aluminum absorber plates, a significant number of manufacturers (over 20) have opted for the use of a standard, prefabricated absorber unit with integral tubes and headers. This introduces a degree of standardization through a major collector component, and provides opportunities for mass production and associated improvements in research, development and quality control.

K. Projections from Collector Panel and Location

Projections from a flat plate collector determine the density of the collector array in a horizontal and/or vertical direction, and the mounting configurations that are possible.

In general, projections include inlet and outlet pipes or ducts for connection with other collectors or the transport system for the heat transfer medium, and mounting brackets or flanges for collector installation integral with a roof, supported on a roof or other supporting surface, or on a rack or mounting frame.

Functional projections can increase the centerline spacing (coordinating dimensions) of collectors used in parallel or in series.

To simplify the description of such projections, it is suggested that a code be developed to indicate their locations and configurations, and recommendations to this effect are made in Part 2.7 and Appendix 6.

L. Weight of Panel

Although the weight (mass) of a collector panel is not a dimensional property, it has some relationship to system design and installation considerations, especially with regard to loads superimposed on support structures. Some manufacturers express collector weight in terms of mass per unit area (lb/ft^2), which simplifies structural design calculations.

M. Comments and Remarks

This item was added to allow the introduction of relevant information of an ancillary or commentary nature. For example, where collectors have been tested at the Florida Solar Energy Center, the Remarks show the resulting availability of technical data by the reference "Tested at FSEC."

Other comments may be addressed to additional dimensional information, existence of other or similar models, flow patterns of heat transfer mediums, materials used for the collector housing, mounting information, etc.

APPENDIX 1

FLAT PLATE COLLECTORS -

LIQUID

FLAT PLATE COLLECTORS - LIQUID

Collector Characteristics	MANUFACTURER AND LOCATION Aircraftsman Millbrook Alabama 36054	Halstead & Mitchell Scottsboro Alabama 35768	National Energy Systems Birmingham Alabama 35201
A Collector Panel: Model Name/No.	A2 (20)	SunCeiver II (14)	A-32-D (21)
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	35.625" [905 mm]* 77.625" [1972 mm]* 5.125"	35.375" [899 mm] 77.375" [1965 mm] 4.00" [102 mm]	37.0" [940 mm] 99.0" [2515 mm] 4.0" [102 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	35.5" [902 mm] 77.5" [1968 mm] 5.25" [133 mm]	35.375" [899 mm] 77.5" [1968 mm] 4.00" [102 mm]	
D Gross Area of Panel (ft^2) [m^2]	19.11 ft^2 [1.78 m^2]	19.04 ft^2 [1.77 m^2]	25.44 ft^2 [2.36 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]	36.0" [914 mm]		
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	ASG Sunadex temp. glass water white 1/8" [3.2 mm]	ASG Sunadex--double gl 34.0" [864 mm] 76.0" [1930 mm] 2 x 1/8" [2 x 3.2 mm]	
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]	33.25" [845 mm] 75.25" [1911 mm]	32.75" [832 mm] 74.875" [1902 mm]	
H Net Aperture Area (ft^2) [m^2]	17.38 ft^2 [1.61 m^2]	17.03 ft^2 [1.58 m^2]	
I Aperture as % of Gross Area	90.9%	89.4%	
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	Copper tube with al. fins 75" long copper tubes	Copper tube with al. fin 34.0" [864 mm] 75.0" [1905 mm]	
K Projections from Collector Panel and Location	Top: 1.5" [38 mm] Bottom: 1.75" [44 mm]	Sides: 0.5" O.D. pipes 3.5" to 3.75"	
L Weight of Panel Empty (lb) [kg] Full (lb) [kg]	90 lb [40.8 kg]	127 lb [57.6 kg] 135 lb [61.2 kg]	
M Comments/Remarks:	*Collector housing dimensions 35.5" x 77.5" Listed dimensions are for glazing frame.	Various sources of information with minor variations. Dimensions of case (al. frame and pan): 34.375" x 76.375"	

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Solar Unlimited, Inc. Huntsville Alabama 35805	Solar Unlimited, Inc. Huntsville Alabama 35805	Solar Unlimited, Inc. Huntsville Alabama 35805
A Collector Panel: Model Name/No.	Suncatcher SH-21 (11)	Suncatcher SH-11	Model H1 Suncatcher
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	35.375" [899 mm] 158.5" [4026 mm]* 4.0" [102 mm]	35.375" [899 mm] 82.0" [2083 mm]* 4.0" [102 mm]	35.375" [899 mm] 77.375" [1965 mm] 4.0" [102 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	35.5" [902 mm] 160.0" [4064 mm]* 4.125" [105 mm]		
D Gross Area of Panel (ft^2) [m^2]	39.44 ft^2 [3.66 m^2]	20.14 ft^2 [1.87 m^2]	19.0 ft^2 [1.77 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]	36.0" [914 mm]	36.0" [914 mm]	36.0" [914 mm]
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	ASG Sunadex temp. glass 2 pieces 1/8" [3.2 mm]	ASG Sunadex temp. glass 1/8" [3.2 mm]	ASG Sunadex temp. gl. 2 x 1/8" [2 x 3.2 mm]
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]	32.5" [825 mm] 150.5" [3823 mm]		
H Net Aperture Area (ft^2) [m^2]	33.97 ft^2 [3.16 m^2]		17.2 ft^2 [1.60 m^2]
I Aperture as % of Gross Area	87.4%		90.5%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	1/2" copper tube with al. fins (203 ft^2)	1/2" copper tube with al. fins (96 ft^2)	Serpentine copper tube bonded to al. fins
K Projections from Collector Panel and Location	*Manifold Cover top or side	*Manifold cover top or side	Copper pipe 0.5"ϕ at side
L Weight of Panel Empty (lb) [kg] Full (lb) [kg]	147 lb [66.7 kg] 158 lb [71.7 kg]	85 lb [38.5 kg] 91 lb [38.6 kg]	135 lb [61.2 kg]
M Comments/Remarks:	*Includes external manifold cover 6.5" x 3.5" [165 mm x 89 mm] at end. Area excluding manifold is 37.8 ft^2 [3.52 m^2]. Horizontal or vertical mounting of collector.	*Includes ext. manifold cover 6.5" x 3.5".	Complete series flow through collector. Also available in single glass model.

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

	Collector Characteristics	Solar Unlimited, Inc. Huntsville Alabama 35805	Sunshine Unlimited Chandler Arizona 85224	Alten Corporation Mountain View California 94043
A	Collector Panel: Model Name/No.	Model H2 Suncatcher	A-Style Vertical (102)	
B	Listed Panel Dimensions: Width (in) [mm]	35.875" [911 mm]	36.25" [921 mm]	46.75" [1187 mm]
	Length (in) [mm]	77.375" [1965 mm]	154.0" [3912 mm]	92.75" [2356 mm]
	Depth (in) [mm]	4.0" [102 mm]	3.5" [89 mm]	4.75" [121 mm]
C	Measured Panel Dimensions: Width (in) [mm]		36.125" [918 mm]	
	Length (in) [mm]		154.4" [3923 mm]	
	Depth (in) [mm]		3.56" [90 mm]	
D	Gross Area of Panel (ft^2) [m^2]	19.28 ft^2 [1.79 m^2]	38.73 ft^2 [3.60 m^2]	30.1 ft^2 [2.80 m^2]
E	Coordinating Dimensions: Width (in) [mm]			
	Length (in) [mm]			
F	Cover Plate Material(s) and Dimensions: Width (in) [mm]	Sunadex temp. gl.-single	Safety plate glass 34.0" [864 mm]	Temp. glass, double st.
	Length (in) [mm]		76.0" [1930 mm]	
	Thickness (in) [mm]	1/8" [3.2 mm]	3/16" [4.8 mm]	3/16" [4.8 mm]
G	Net Aperture Dimensions Width (in) [mm]		32.75" [832 mm]	
	Length (in) [mm]		150.75" [3829 mm]	
H	Net Aperture Area (ft^2) [m^2]		34.29 ft^2 [3.19 m^2]	
I	Aperture as % of Gross Area		88.5%	
J	Absorber Material(s) and Size Width (in) [mm]	Copper tube 0.5"ø with al. fins	Copper 3/8" tube, alum. 0.020"	Ext. al. fins pressed on copper tubing
	Length (in) [mm]			
K	Projections from Collector Panel and Location		Sides-1" nom. header pipe	
L	Weight of Panel Empty (lb) [kg]	80 lb [36.3 kg]	158 lb [71.7 kg]	
	Full (lb) [kg]	87 lb [39.5 kg]		
M	Comments/Remarks:	Can be mounted horizontally or vertically, flat or tilted. Liquid flow is serpentine. Al. manifold cover may be used.	Central expansion joint between glass cover sheets. Aluminum encased redwood frame 3.5" x 1.5"	

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	American HCP, Inc. San Francisco California 94080	American Home Solar Energy Systems Laguna Beach California 92651	American Solar Indust. Concord California 94521
A Collector Panel: Model Name/No.	S-240-G (162)	NOVA	Raymaster I (130)
B Listed Panel Dimensions: Width (in) [mm] / Length (in) [mm] / Depth (in) [mm]	48.0" [1219 mm] / 120.0" [3048 mm] (4x10)	48.0" [1219 mm] / 96.0" [2438 mm] / 3.25" [83 mm]	48.0" [1219 mm] / 96.0" [2438 mm]
C Measured Panel Dimensions: Width (in) [mm] / Length (in) [mm] / Depth (in) [mm]	47.0" [1194 mm] / 120.0" [3048 mm] / 2.5" [64 mm]		48.5" [1232 mm] / 94.625" [2403 mm] / 3.25 [83 mm]
D Gross Area of Panel (ft^2) [m^2]	39.16 ft^2 [3.64 m^2]	32.0 ft^2 [2.97 m^2]	31.87 ft^2 [2.96 m^2]
E Coordinating Dimensions: Width (in) [mm] / Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm] / Length (in) [mm] / Thickness (in) [mm]	Filon Sup. Grade with Tedlar film	Reinf. polyester Filon	Herculite temp. glass / 3/16" [4.8 mm]
G Net Aperture Dimensions Width (in) [mm] / Length (in) [mm]	45.0" [1143 mm] / 116.125" [2950 mm]		45.0" [1143 mm] / 91.625" [2327 mm]
H Net Aperture Area (ft^2) [m^2]	36.3 ft^2 [3.37 m^2]	29.42 ft^2 [2.73 m^2]	28.6 ft^2 [2.66 m^2]
I Aperture as % of Gross Area	92.6%		89.9%
J Absorber Material(s) and Size Width (in) [mm] / Length (in) [mm]	Polypropylene 0.035"	Copper abs. plate 0.040" fin, 0.020"w.w.	Aluminum fin
K Projections from Collector Panel and Location			Sides: Nom. 1" copper headers, 2.5" from edge
L Weight of Panel Empty (lb) [kg] / Full (lb) [kg]	65 lb [29.5 kg] / 90 lb [40.8 kg]		210 lb [95.3 kg]
M Comments/Remarks:	Also Model S-232-G (4' x 8' nom.) with 28.9 ft^2 aperture area	Redwood frame Absorber plate has integral water ways	

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Approtech San Jose California 95110	Colt, Inc. of Southern California Rancho Mirage California 92270	Conserdyne Corporation Glendale California 91204
A Collector Panel: Model Name/No.	Solaristocrat	Colt A-151 (1)	S-1, 3' x 10' (128)
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	48.0" [1219 mm] 78.0" [1981 mm]	35.0" [889 mm] 96.0" [2438 mm] 3.25" [83 mm]	38.31" [973 mm] 120.0" [3048 mm] 4.5" [114 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]		35.0" [889 mm] 96.0" [2438 mm] 3.25" [83 mm]	
D Gross Area of Panel (ft^2) [m^2]	26.0 ft^2 [2.42 m^2]	23.33 ft^2 [2.17 m^2]	31.93 ft^2 [2.97 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]	48.0" cs. [1219 mm cs.]		
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Low-iron temp. glass 46.0" [1168 mm] 76.0" [1930 mm]	Low-iron temp. glass 1/8" [3.2 mm]	Sunadex temp. glass 3/16" [4.8 mm]
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]		32.0" [813 mm] 93.0" [2362 mm]	33.0" [838 mm] 115.0" [2921 mm]
H Net Aperture Area (ft^2) [m^2]	23.44 ft^2 [2.18 m^2]	20.67 ft^2 [1.92 m^2]	26.35 ft^2 [2.45 m^2]
I Aperture as % of Gross Area	90.2%	88.6%	82.5%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	Sunlock al. plate 0.050" with 1/2" copper tube	Aluminum Roll-bond 0.060" 34.0" [864 mm] 95.0" [2413 mm]	Stainless steel 0.024"
K Projections from Collector Panel and Location		Inlet/outlet diagonally oppos., 1.5" at ends	
L Weight of Panel Empty (lb) [kg] Full (lb) [kg]	132 lb [59.9 kg]	93 lb [42.2 kg]	184.5 lb [83.7 kg]
M Comments/Remarks:	Anchor brackets permit panel through 60° arc for seasonal adjustment. Installation at 48" cs.	Also available Model C-151 with a copper Roll-bond absorber plate 0.040"; panel weight 116 lb [62.6 kg]	Alternative model S1A (3' x 6' nominal)- See next page.

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Conserdyne Corporation Glendale California 91204	Energy Systems, Inc. San Diego California 92120	Insolarator Specialty Manuf. Inc. San Diego California 92111
A Collector Panel: Model Name/No.	S1A (128)	1111D (127)	SAI20-125 SS (30)
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	38.31" [973 mm] 80.31" [2040 mm] 4.5" [114 mm]	36.0" [914 mm] 78.0" [1981 mm] 4.125" [105 mm]	34.5" [876 mm] 76.5" [1943 mm] 4.0" [102 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	39.0" [990 mm] 81.0" [2057 mm] 4.38" [111 mm]	36.0" [914 mm] 78.125" [1984 mm] 4.125" [105 mm]	34.5" [876 mm] 76.38" [1940 mm] 4.0" [102 mm]
D Gross Area of Panel (ft^2) [m^2]	21.94 ft^2 [2.04 m^2]	19.53 ft^2 [1.81 m^2]	18.30 ft^2 [1.70 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Tru-Temp safety glass 3/16" [4.8 mm]	Temp. plate glass 2 x 1/8" [2 x 3.2 mm]	Temp. safety glass single or double 1/8" [3.2 mm]
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]	33.0" [838 mm] 75.0" [1905 mm]	32.25" [819 mm] 74.5" [1892 mm]	32.88" [835 mm] 75.0" [1905 mm]
H Net Aperture Area (ft^2) [m^2]	17.19 ft^2 [1.60 m^2]	16.68 ft^2 [1.55 m^2]	17.12 ft^2 [1.59 m^2]
I Aperture as % of Gross Area	78.5%	85.5%	93.4%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	Stainless steel 0.024"	Alum 0.0625" with copper passages and headers	Alum. 0.050" with copper risers and headers
K Projections from Collector Panel and Location	3/4" copper pipe adaptors at back near corners	5/8"ø plumbing connect. top and bottom	1-1/4" headers from sides
L Weight of Panel Empty (lb) [kg] Full (lb) [kg]	123.5 lb [56.0 kg]	126 lb [57.2 kg] 130 lb [59.0 kg]	88 lb [40 kg] 94 lb [42.6 kg]
M Comments/Remarks:		Also 1111S (single pane) 100 lb filled weight. Collector may be mounted with long or short dimension horizontal.	Housing: Lexan 0.125" (polycarbonate) vacuum formed. Also Model 125 D-double glazed--Wt. 125 lb full

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	International Solar Leasing Co. San Diego California 92111	Pacific Solar Systems Inc. Modesto California 95355	Piper Hydro, Inc. Anaheim California 92806
A Collector Panel: Model Name/No.	I.S.L.C. C-9121 (134)	100C (151)	Model 3000 (123)
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	34.25" [870 mm] 96.5" [2451 mm]	48.0" [1219 mm] 120.0" [3048 mm]	24.0" [610 mm] 96.0" [2438 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	34.25" [870 mm] 96.625" [2454 mm] 3.25" [83 mm]	48.125" [1224 mm] 121.125" [3077 mm]	23.83" [605 mm] 96.125" [2442 mm] 3.25" [83 mm]
D Gross Area of Panel (ft^2) [m^2]	22.98 ft^2 [2.14 m^2]	40.48 ft^2 [3.76 m^2]	15.91 ft^2 [1.48 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	ASG Sunadex 1/8" [3.2 mm]	Sunadex 5/32" [4.0 mm]	0.004" Tedlar plus 0.001" Teflon
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]	32.375" [822 mm] 94.75" [2407 mm]	45.125" [1146 mm] 118.125" [3000 mm]	21.83" [554 mm] 92.375" [2346 mm]*
H Net Aperture Area (ft^2) [m^2]	21.30 ft^2 [1.98 m^2]	37.02 ft^2 [3.44 m^2]	14.00 ft^2 [1.30 m^2]
I Aperture as % of Gross Area	92.7%	91.5%	88.1%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	Olin Brass Standard Copper 0.040"; Al.0.060"	Olin Brass Copper roll-bond 0.040"	Al. extr. absorber with 0.5" copper tubes
K Projections from Collector Panel and Location	Copper connecting pipe top and bottom	1.5" nom. copper header both sides	
L Weight of Panel Empty (lb) [kg] Full (lb) [kg]	115 lb [52.2 kg]	118 lb [53.5 kg]	62 lb [28.1 kg]
M Comments/Remarks:		Has vacuum-formed ABS collector pan.	*3 supports for glazing @ 23.5" cs. approx. 1" drain lip at bottom end of collector.

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Raypak, Inc. Westlake Village California 91359	Solar Energy Products, Inc.* Santa Rosa California 95402	Solar Energy Systems, Inc. Los Angeles California 90058
A Collector Panel: Model Name/No.	DG/SG-18P	CU 30-WW (149)	Model 218
B Listed Panel Dimensions: Width (in) [mm]	37.5" [952 mm]	48.5" [1232 mm]	36.0" [914 mm]
Length (in) [mm]	79.5" [2019 mm]*	98.5" [2502 mm]	70.0" [1778 mm]
Depth (in) [mm]	4.25 [108 mm]	2.57" [65 mm]	4.0" [102 mm]
C Measured Panel Dimensions: Width (in) [mm]		48.5" [1232 mm]	
Length (in) [mm]		98.5" [2502 mm]	
Depth (in) [mm]		2.6" [66 mm]	
D Gross Area of Panel (ft^2) [m^2]	20.70 ft^2 [1.92 m^2]	33.18 ft^2 [3.08 m^2]	17.5 ft^2 [1.63 m^2]
E Coordinating Dimensions: Width (in) [mm]			
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions:	temp. water white single [SG] or double [DG]	Waterwhite temp. glass	Low iron temp. glass*
Width (in) [mm]		46.0" [1168 mm] (85.5 lb)	
Length (in) [mm]		96.0" [2438 mm]	
Thickness (in) [mm]		3/16" [4.8 mm]	1/8" [3.2 mm]
G Net Aperture Dimensions Width (in) [mm]		45.375" [1153 mm]	
Length (in) [mm]		95.375" [2423 mm]	
H Net Aperture Area (ft^2) [m^2]	17.3 ft^2 [1.61 m^2]	30.05 ft^2 [2.79 m^2]	
I Aperture as % of Gross Area	83.6%	90.6%	
J Absorber Material(s) and Size Width (in) [mm]	0.020" Alum. plate with 0.375" copper tubes	0.5" i.d. copper tube with extr. alum. wings	0.375" i.d. copper tube with 4" extr. alum. fins
Length (in) [mm]			
K Projections from Collector Panel and Location	*82.25" [2089 mm] length over fastenings		
L Weight of Panel Empty (lb) [kg]	SG: 105 lb [47.6 kg]	190 lb [86.2 kg]	96 lb [43.5 kg]
Full (lb) [kg]	DG: 135 lb [61.2 kg]		
M Comments/Remarks:		Affiliated with Solar Energy Products, Inc. of Gainesville, Florida Horizontal and vertical roof mounting; l.h. and r.h. end outlet options	Also available with U.V. stabilized clear base fiberglass cover; Weight 68 lb [30.8 kg]

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Solar Energy Systems, Inc. Los Angeles California 90058	Solar Science Industries Hollywood Ltd. California 91605	Solergy Inc. San Francisco California 94107
A Collector Panel: Model Name/No.	Model 232 (Model 240**)	Banit D-36-GS (145)	Solergy Model 1-A (72)
B Listed Panel Dimensions: Width (in) [mm]	48.0" [1219 mm]	34.0" [864 mm]	48.0" [1219 mm]
Length (in) [mm]	96.0" [2438 mm]	74.0" [1880 mm]	96.0" [2438 mm]
Depth (in) [mm]	4.0" [102 mm]	2.5" [64 mm]	
C Measured Panel Dimensions: Width (in) [mm]		34.75" [883 mm]	48.1875" [1224 mm]
Length (in) [mm]		74.3" [1887 mm]	96.1875" [2443 mm]
Depth (in) [mm]		2.75" [70 mm]	4.375" [111 mm]
D Gross Area of Panel (ft^2) [m^2]	32.0 ft^2 [2.97 m^2]	17.93 ft^2 [1.67 m^2]	32.19 ft^2 [2.99 m^2]
E Coordinating Dimensions: Width (in) [mm]			
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm]	Low-iron temp. glass*	Tempered safety glass	Outer: Acrylite FF 1/8" Inner: 0.001" Teflon
Length (in) [mm]			
Thickness (in) [mm]	1/8" [3.2 mm]	1/8" [3.2 mm]	
G Net Aperture Dimensions Width (in) [mm]		32.625" [829 mm]	46.25" [1175 mm]
Length (in) [mm]		72.25" [1835 mm]	94.25" [2394 mm]
H Net Aperture Area (ft^2) [m^2]		16.37 ft^2 [1.52 m^2]	30.27 ft^2 [2.81 m^2]
I Aperture as % of Gross Area		91.3%	94.0%
J Absorber Material(s) and Size Width (in) [mm]	11- 0.375" copper tubes with 4" extr. alum. fins	Cold rolled steel 0.59" chamber, 0.049" thick	
Length (in) [mm]			
K Projections from Collector Panel and Location			Inlet/Outlet 2.375" at sides (bottom & top)
L Weight of Panel Empty (lb) [kg]	157 lb [71.2 kg]	97 lb [44 kg]	75 lb [34 kg]
Full (lb) [kg]			
M Comments/Remarks:	*Also avail. with fiber-glass cover; weight 105 lb [47.6 kg] ** Model 240 (48" x 120") Weight: 196 lb with 1/8" glass cover; 130 lb with fiberglass cover.	2 types: A: end inlet end outlet B: side inlet side outlet	

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Solar II Enterprises Campbell California 95030	Southwest Solar Corp'n Canoga Park California 91304	Sunburst Solar Energy, Inc. Menlo Park California 94025
A Collector Panel: Model Name/No.	CG-231 (39)	Solar Disc 1000 (70)	BEA 48
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	36.0" [914 mm] 98.0" [2489 mm] 3.5" [89 mm]	23.0" [584 mm] plus lips 96.0" [2438 mm] 2.5" [64 mm]	48.0" [1219 mm] 96.0" [2438 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	35.875" [911 mm] 98.0" [2489 mm] 3.5" [89 mm]	23.0" [584 mm] 95.75" [2432 mm] 2.5" [64 mm]	
D Gross Area of Panel (ft^2) [m^2]	24.41 ft^2 [2.27 m^2]	15.29 ft^2 [1.42 m^2]	32.0 ft^2 [2.97 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]		24.0" [610 mm]	
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Sunadex tru-temp glass 3/16" [4.8 mm]	Temp. safety glass 3/16" [4.8 mm]	ASG Sunadex W.W. temp. 3/16" [4.8 mm]
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]	33.125" [841 mm] 95.25" [2419 mm]	21.25" [540 mm] 93.375" [2372 mm]	45.6" [1158 mm] 94.0" [2388 mm]
H Net Aperture Area (ft^2) [m^2]	21.91 ft^2 [2.04 m^2]	13.8 ft^2 [1.28 m^2]	29.77 ft^2 [2.77 m^2]
I Aperture as % of Gross Area	89.8%	90.1%	93.0%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	Olin Brass Rollbond 9121 copper absorber 0.040"	Olin Solar Bond 0.040"	Copper plate 0.016" w. 0.5" O.D. tube grid
K Projections from Collector Panel and Location	0.5" nom. copper pipe, 1.5" proj. top & bottom ends	Hinged extrusion for fixing-collector ends	
L Weight of Panel Empty (lb) [kg] Full (lb) [kg]	111 lb [50.3 kg] 119 lb [54 kg]	75 lb [34 kg]	132 lb [59.9 kg] 139 lb [63 kg]
M Comments/Remarks:	Extruded alum. frame	Usually sold in pairs. Interlocking lips-side. Hinge stand-off 2".	Model BG-48 with 8-oz. tedlar coated fibergl. (Glasteel) and alum. absorber plate: weight empty 66 lb [30 kg] and full 72 lb [32.7 kg].

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Sun Power Systems, Ltd. Sunnyvale California 98046	Sun Power Systems, Ltd. Sunnyvale California 98046	TechniTrek Corp. San Leandro California 94577
A Collector Panel: Model Name/No.	Sun-Panel C38B-S	Sun-Panel C38B-H (29)	Thermo Trek 36-120E
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	36.375" [924 mm] 96.0" [2438 mm] 3.5" [89 mm]	36.375" [924 mm] 102.0" [2591 mm] 3.5" [89 mm]	38.0" [965 mm] 124.0" [3150 mm] 3.5" [89 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]		36.437" [925 mm] 102.0" [2591 mm] 3.5625" [90 mm]	
D Gross Area of Panel (ft^2) [m^2]	24.25 ft^2 [2.25 m^2]	25.81 ft^2 [2.40 m^2]	32.72 ft^2 [3.04 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]	36.5" [927 mm]	36.5" [927 mm] 102.25" [2597 mm]	
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Water white temp. glass 3/16" [4.8 mm]	Water white temp. glass 3/16" [4.8 mm]	Acrylic
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]		34.06" [865 mm] 100.0" [2540 mm]	
H Net Aperture Area (ft^2) [m^2]		23.65 ft^2 [2.2 m^2]	30.0 ft^2 [2.79 m^2]
I Aperture as % of Gross Area		91.8%	91.7%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	Olin Solar-Bond copper	Olin Solar-Bond copper RS 9121	Copper plate 0.020" w. 3/8" tubes @ 6" cs.
K Projections from Collector Panel and Location	Inlet/outlet diagonally oppos., 3" projection	Snap-fit header pipe connection, 1.25"	Inlet/Outlet-sides, 2.75" [70 mm] project.
L Weight of Panel Empty (lb) [kg] Full (lb) [kg]		140 lb [63.5 kg] 148 lb [67.1 kg]	140 lb [63.5 kg] 143 lb [64.9 kg]
M Comments/Remarks:	Without internal header pipes. Can be connected in parallel or in series (max. two collectors in series)	With internal header pipes and patented snap-coupling. Connection in parallel	

MANUFACTURER AND LOCATION

Collector Characteristics	Western Energy, Inc. Palo Alto California 94302	Ying Manuf. Corporation Gardena California 90249	Solarcoa, Inc. Long Beach California 90806
A Collector Panel: Model Name/No.	Solera™3492 (46)	SP4120 (73)	Model 32
B Listed Panel Dimensions: Width (in) [mm]	35.0" [889 mm]	49.5" [1257 mm]	48.0" [1219 mm]
Length (in) [mm]	93.0" [2362 mm]	145.5" [3696 mm]	96.0" [2438 mm]
Depth (in) [mm]	3.5" [89 mm]	4.1" [104 mm]	4.0" [102 mm]
C Measured Panel Dimensions: Width (in) [mm]	34.75" [883 mm]	49.5" [1257 mm]*	
Length (in) [mm]	92.75" [2356 mm]	145.5" [3696 mm]*	
Depth (in) [mm]	3.5" [89 mm]	4.125" [105 mm]	
D Gross Area of Panel (ft^2) [m^2]	22.38 ft^2 [2.08 m^2]	50.02 ft^2 [4.65 m^2]	32.0 ft^2 [2.97 m^2]
E Coordinating Dimensions: Width (in) [mm]			
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm]	Clear temp. glass	0.020" Lexan U.V. stabilized clear polycarbon.	Twinwall Polycarbonate
Length (in) [mm]			
Thickness (in) [mm]	3/16" [4.8 mm]	0.020" [0.5 mm] Supports @ 35" cs	
G Net Aperture Dimensions Width (in) [mm]	33.0" [838 mm]	46.5" [1181 mm]	
Length (in) [mm]	91.0" [2311 mm]	139.5" [3543 mm]	
H Net Aperture Area (ft^2) [m^2]	20.85 ft^2 [1.94 m^2]	45.05 ft^2 [4.18 m^2]	29.0 ft^2 [2.69 m^2]
I Aperture as % of Gross Area	93.3%	89.7%	90.6%
J Absorber Material(s) and Size Width (in) [mm]	0.010" copper plate with 0.5" serpentine tubes	Alum. 0.050" with st.st. 0.5"ø grid, 1" headers	Al. plate with copper tubes 0.5" @ 4.5" cs.
Length (in) [mm]			
K Projections from Collector Panel and Location	0.5" mounting flange all edges, 1" header-sides	0.75" mounting flange at bottom; headers,	
L Weight of Panel Empty (lb) [kg]	95 lb [43 kg]	110 lb [49.9 kg]	75 lb [34 kg]
Full (lb) [kg]	100 lb [45.4 kg]		80 lb [36.3 kg]
M Comments/Remarks:	Mounting flange as built-in nailing strip, 0.5" all round. Serpentine flow pattern.	* Dimensions include a 0.75" mounting flange all round; net size 48.0" x 144.0"	Formerly: Solar Conversion Corporation of America.

MANUFACTURER AND LOCATION

Collector Characteristics	American Heliothermal Corp. Denver Colorado 80223	Federal Energy Corporation Denver Colorado 80022	Hyperion, Inc. Boulder Colorado 80301
A Collector Panel: Model Name/No.	Miromit Model 200	F- 200 (52)	SPW-1001 (15)
B Listed Panel Dimensions: Width (in) [mm]	42.125"[1070 mm]	34.0625" [865 mm]	35.75" [908 mm]
Length (in) [mm]	79.53" [2020 mm]	74.5" [1892 mm]	77.75" [1975 mm]
Depth (in) [mm]	5.31" [135 mm]	3.375" [86 mm]	4.625" [117 mm]
C Measured Panel Dimensions: Width (in) [mm]		34.125" [867 mm]	35.875" [911 mm]
Length (in) [mm]		74.625" [1895 mm]	77.875" [1978 mm]
Depth (in) [mm]		3.75" [95 mm]	5.0" [127 mm]
D Gross Area of Panel (ft^2) [m^2]	23.27 ft^2 [2.16 m^2]	17.68 ft^2 [1.64 m^2]	19.40 ft^2 [1.80 m^2]
E Coordinating Dimensions: Width (in) [mm]			36.0" [914 mm]
Length (in) [mm]			80.0" [2032 mm]
F Cover Plate Material(s) and Dimensions: Width (in) [mm]	ASG water white glass	Outer:0.095" mod. acrylic Inner:1/8" temp. plate gl. Glass: 32.25" [819 mm]	ASG Low-iron temp. glass
Length (in) [mm]		2 x 35.75" [908 mm]	
Thickness (in) [mm]	5/32" [4.0 mm]		1/8" [3.2 mm]
G Net Aperture Dimensions Width (in) [mm]		31.625" [803 mm]	33.0" [838 mm]
Length (in) [mm]		69.875" [1775 mm]	75.25" [1911 mm]
H Net Aperture Area (ft^2) [m^2]	20.5 ft^2 [1.9 m^2]	15.35 ft^2 [1.43 m^2]	17.24 ft^2 [1.60 m^2]
I Aperture as % of Gross Area	88.2%	86.8%	89.0%
J Absorber Material(s) and Size Width (in) [mm]	Galv. steel abs. and tubes 1 mm thick	Steel, 0.042" riser 0.133" header 30.625" [778 mm]	24 gauge steel with copper tubes @ 2.75" cs
Length (in) [mm]		65.5" [1664 mm]	
K Projections from Collector Panel and Location			0.75" copper intake and return
L Weight of Panel Empty (lb) [kg]	196 lb [88.9 kg]	103 lb [46.7 kg]	125 lb [56.7 kg]
Full (lb) [kg]	204 lb [92.5 kg]		
M Comments/Remarks:	Miromit components are manufactured in Israel in metric dimensions. Optional end-, side-, or back-piped collectors.	Outer cover-modified acrylic, vacuum formed zig-zag pattern. Glass cover--2 sheets with central support.	Fixing centers 78.875" overall length 80.0" Plumbing of 2-3 in series.

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Novan Energy* Boulder Colorado 80301	R-M Products, Inc. Denver Colorado 80216	American Solar Heat Corp'n. Danbury Connecticut 06810
A Collector Panel: Model Name/No.	EC-200L (22)	R-M Sun-Grabber	Amsolheat Solar Panel (10)
B Listed Panel Dimensions: Width (in) [mm]	35.875" [911 mm]	24.0" [610 mm]	48.0" [1219 mm]*
Length (in) [mm]	77.875" [1978 mm]	120.0" [3048 mm]	96.0" [2438 mm]*
Depth (in) [mm]	4.125" [105 mm]	5.5" [140 mm]	
C Measured Panel Dimensions: Width (in) [mm]	36.00" [914 mm]		48.1" [1222 mm]
Length (in) [mm]	78.00" [1981 mm]		96.125" [2442 mm]
Depth (in) [mm]	4.25" [108 mm]		3.125" [79 mm]
D Gross Area of Panel (ft^2) [m^2]	19.5 ft^2 [1.81 m^2]	20.0 ft^2 [1.86 m^2]	32.11 ft^2 [2.98 m^2]
E Coordinating Dimensions: Width (in) [mm]	36.00" [914 mm]		
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions:	Sunadex temp. glass	Low-iron temp. glass	Impact resistant fiber-glass Kalwall 0.040"
Width (in) [mm]			
Length (in) [mm]			
Thickness (in) [mm]	1/8" [3.2 mm]	1/8" [3.2 mm]	0.040" [1.0 mm]
G Net Aperture Dimensions Width (in) [mm]	33.5" [851 mm]		45.5" [1156 mm]
Length (in) [mm]	75.5" [1918 mm]		93.5" [2375 mm]
H Net Aperture Area (ft^2) [m^2]	17.56 ft^2 [1.63 m^2]		29.54 ft^2 [2.74 m^2]
I Aperture as % of Gross Area	90.0%	87.5%	92.0%
J Absorber Material(s) and Size Width (in) [mm]	Olin Brass Roll Bond copper 0.040" FS:9121	Copper absorber	Copper 0.005" with 12 1/4"ø tubes;
Length (in) [mm]			
K Projections from Collector Panel and Location	Inlet/outlet, 0.5" copper top and bottom; 0.75" alum. flange all 4 sides		0.5" manifold on sides 1.0" [25 mm] diag. opp.
L Weight of Panel Empty (lb) [kg]	102 lb [46.3 kg]	(5.6 lb per nom. ft^2)	48 lb [21.8 kg]
Full (lb) [kg]			
M Comments/Remarks:	* formerly: Alternative Heating Systems, Inc. **Dimensions are accurate to ±0.125" to accommodate absorber plate irregularities.	Standard length 120"; optional lengths: 96", 144", 180", 240", 300". Mounting @ 24" cs.	Technical literature states 1.2 m x 2.4 m *

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	National Solar Corporat'n Essex Connecticut 06426	Sunworks, Div. of Enthone Inc. New Haven Connecticut 06508	Porter Energy Products Newark Delaware 19711
A Collector Panel: Model Name/No.	Model NSC 100 (55)	Solector LB10010 (13)	Solaris[412] (35)
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	36.0" [914 mm] 96.0" [2438 mm]	35.5" [902 mm] 84.0" [2134 mm] 4.0" [102 mm]	47.5" [1206 mm] 150.75" [3829 mm] 4.375" [111 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	37.125" [943 mm] 99.375" [2524 mm] 4.375" [111 mm]	35.5" [902 mm] 84.0" [2134 mm]	47.4375" [1205 mm] 150.56" [3824 mm] 5.0" [127 mm]
D Gross Area of Panel (ft^2) [m^2]	25.62 ft^2 [2.38 m^2]	20.71 ft^2 [1.92 m^2]	49.60 ft^2 [4.61 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]		36.0" [914 mm] Module 90.0" [2286 mm]	48.0" [2438 mm]
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Double-Low-iron temp. gl. 2 x1/8" [2 x 3.2 mm]	Low-iron ASG temp. glass 1/8" [3.2 mm]	6 panels: 1/8" glass 45.625" [1159 mm] 6 x 22.625" [575 mm] 1/8" [3.2 mm]
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]	32.875" [835 mm] 95.125" [2416 mm]	33.25" [845 mm] 81.875" [2080 mm]	45.5625" [1157 mm] 135.75" [3448 mm]
H Net Aperture Area (ft^2) [m^2]	21.7 ft^2 [2.02 m^2]	18.90 ft^2 [1.76 m^2]	42.95 ft^2 [3.99 m^2]
I Aperture as % of Gross Area	84.9%	91.3%	86.6%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	Continuous flat copper tubing 0.021" wall	Copper sheet 0.010" with 3/8" risers @ 6" cs. 33.0" [838 mm] 81.0" [2057 mm] incl.	Alum. corr. and embossed 0.018"
K Projections from Collector Panel and Location	Inlet/outlet at back 1.5" to 2" [38 to 50 mm]	Add 1.25" each end for cont. mounting bracket	Outlet, 1.1875" [30 mm]
L Weight of Panel Empty (lb) [kg] Full (lb) [kg]	175 lb [79.4 kg]	120 lb [54.4 kg]	(2.5 lb/ft^2)
M Comments/Remarks:	Also available as NSC collector module. 6.0" [150 mm] standoff above roof recommended.	3'-0" [914 mm] row spacing; For double glazing add 32 lb [14.5 kg]	* Including closed-in manifold at top; housing 146.75" long

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Aztec Solar Co. Maitland Florida 32751	D.W. Browning Contracting Co. Holy Hill Florida 32017	C.B.M. Manufacturing Inc. Fort Lauderdale Florida 33311
A Collector Panel: Model Name/No.	Sundevil III (71)	Model B (45)	Model 20-34-92 (141)
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	22.375" [568 mm] 60.00" [1524 mm] 3.5" [89 mm]	40.0" [1016 mm] 118.25" [3004 mm] 3.0625" [78 mm]	34.0" [864 mm] 92.0" [2337 mm] 4.0" [102 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	23.75" [603 mm] 61.50" [1562 mm] 3.5" [89 mm]	40.25" [1022 mm] 118.5" [3010 mm] 3.25" [83 mm]	34.625" [879 mm] 92.625" [2353 mm] 4.25" [108 mm]
D Gross Area of Panel (ft^2) [m^2]	10.14 ft^2 [0.94 m^2]	33.12 ft^2 [3.08 m^2]	22.27 ft^2 [2.07 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]	24.0" [610 mm]		
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Kalwall Sunlite Premium FRP 0.040" [1,0 mm]	Dupont Tedlar 0.004" [0.1 mm]	Low-iron temp. glass 3/16" [4.8 mm]
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]	22.25" [565 mm] 60.00" [1524 mm]	38.0625" [967 mm] 116.375" [2956 mm]	31.625" [803 mm] 89.625" [2276 mm]
H Net Aperture Area (ft^2) [m^2]	9.27 ft^2 [0.86 m^2]	30.76 ft^2 [2.86 m^2]	19.68 ft^2 [1.83 m^2]
I Aperture as % of Gross Area	91.6%	92.8%	88.4%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	Copper sheet 0.055" with 1/2"ø copper tubes 22.375" (before grooving) 54.0" [1372 mm]	Copper tubing bonded to 2-0.025" al. plates 39.75" [1010 mm] 118.0" [2997 mm]	0.0162" copper plate with 0.040" tubes @ 5" cs. 790 mm 2230 mm
K Projections from Collector Panel and Location	Inlet/outlet at top and bottom, 4" [102 mm]	Inlet/outlet-narrow end 4.25" projection	7/8" O.D. copper headers at sides 1.5"
L Weight of Panel Empty (lb) [kg] Full (lb) [kg]		64.4 lb [29.2 kg]	150 lb [68 kg]
M Comments/Remarks:	Conflicting technical information from different sources. Other Sundevil model 36.25" x 80.25".	Serpentine flow pattern, allowing horizontal or vertical mounting.	

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	CSI Solar Systems Div. Clearwater Florida 33520	General Energy Devices Clearwater Florida 33516	General Energy Devices Clearwater Florida 33516
A Collector Panel: Model Name/No.	Sol-Heet Model 1000C (54)	Model 24-41C (66)	Model 16-41P Solatron
B Listed Panel Dimensions: Width (in) [mm]	48.0" [1219 mm]	38.5" [978 mm]	28.5" [724 mm]
Length (in) [mm]	112.0" [2845 mm]*	105.5" [2680 mm]	113.0" [2870 mm]
Depth (in) [mm]	4.0" [102 mm]	5.0" [127 mm]	6.0" [152 mm]
C Measured Panel Dimensions: Width (in) [mm]	49.75" [1264 mm]	38.1875" [970 mm]	28.1875" [716 mm]
Length (in) [mm]	112.75" [2864 mm]	105.875" [2690 mm]	113.0" [2870 mm]
Depth (in) [mm]	3.625" [92 mm]	5.125" [130 mm]	6.1875" [157 mm]
D Gross Area of Panel (ft^2) [m^2]	38.95 ft^2 [3.62 m^2]	28.09 ft^2 [2.61 m^2]	22.12 ft^2 [2.05 m^2]
E Coordinating Dimensions: Width (in) [mm]			
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions:	6 pieces SS Float glass	Kalwall Sunlite Pr.FRP	FRP
Width (in) [mm]	20.5" [521 mm]		
Length (in) [mm]	48.0" [1219 mm]		
Thickness (in) [mm]	0.125" [3.2 mm]	0.040" [1.0 mm]	0.040" [1.0 mm]
G Net Aperture Dimensions Width (in) [mm]	46.75" [1187 mm]	36.1" [917 mm]	26.25" [666 mm]
Length (in) [mm]	99.375" [2524 mm]	103.5" [2630 mm]	102.375" [2600 mm]
H Net Aperture Area (ft^2) [m^2]	32.26 ft^2 [3.00 m^2]	25.9 ft^2 [2.41 m^2]	18.64 ft^2 [1.73 m^2]
I Aperture as % of Gross Area	82.8%	92.3%	
J Absorber Material(s) and Size Width (in) [mm]	0.026" corr. aluminum with 0.5" I.D. copper t.	Olin Alum. Rollbond exp. sheet	Olin Copper Rollbond expanded sheet & tube
Length (in) [mm]			
K Projections from Collector Panel and Location	Inlet/outlet tubes at one end.		
L Weight of Panel Empty (lb) [kg]	175 lb [79.4 kg]	106 lb [48 kg]	101.5 lb [46 kg]
Full (lb) [kg]			
M Comments/Remarks:	Serpentine flow pattern Also: Model 750C--length: 99.125" [2518 mm]; area: 34.25 ft^2 [3.18 m^2]. *Includes control section compartment one end.	Fiberglass epoxy collector enclosure.	Fiberglass epoxy enclosure. Includes an inbuilt circulation pump and controls.

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Gulf Thermal Corporation Bradenton Florida 33505	Horizon Enterprises Homestead Florida 33030	Raleigh Manuf. Co. Inc. Miami Florida 33147
A Collector Panel: Model Name/No.	CUS 30 WW (28)	H.E.#2400-A (47)	Model 4-1
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	48.5" [1232 mm] 98.5" [2502 mm] 2.56" [65 mm]	36.75" [933 mm] 96.75" [2457 mm] 3.875" [98 mm]	48.1875" [1224 mm] 72.1875" [1834 mm] 4.125" [105 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	48.5" [1232 mm] 98.625" [2505 mm] 2.625" [67 mm]	36.875" [937 mm] 96.875" [2461 mm] 4.0" [102 mm]	48.5" [1232 mm] 72.375" [1838 mm] 4.125" [105 mm]
D Gross Area of Panel (ft^2) [m^2]	33.22 ft^2 [3.09 m^2]	24.81 ft^2 [2.30 m^2]	24.37 ft^2 [2.26 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Temp. Glass 3/16" [4.8 mm]	Kalwall Premium II-FRP 36.0" [914 mm] 96.0" [2438 mm] 0.040" [1.0 mm]	Kalwall Premium II-FRP 0.040" [1.0 mm]
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]	45.375" [1153 mm] 95.25" [2419 mm]	35.0625" [891 mm] 93.75" [2381 mm]	46.5" [1181 mm] [1749 mm]
H Net Aperture Area (ft^2) [m^2]	30.01 ft^2 [2.79 m^2]	22.82 ft^2 [2.12 m^2]	[2.07 m^2]
I Aperture as % of Gross Area	90.3%	92.0%	91.2%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	Extr. alum fin, tapered with 0.5" copper tubes 45.0" [1143 mm] 94.0" [2388 mm]	Copper tube soldered to 0.0216" copper sheet 36.0" [914 mm] 96.0" [2438 mm]	Copper sheet 0.008" with 5/8" O.D. tubes 41.75" [1060 mm] 69.75" [1772 mm]
K Projections from Collector Panel and Location	Connecting header tubes 1.625" top and bottom	Connecting pipes--one side--2.0" [50 mm]	
L Weight of Panel Empty (lb) [kg] Full (lb) [kg]	180 lb [81.6 kg] 188 lb [85.3 kg]	78 lb [35.4 kg] 83 lb [37.6 kg]	75 lb [34 kg]
M Comments/Remarks:	Custom mounting systems for fixed or adjustable installation available. Horizontal mounting.	Cover plate has two 3/4" supports at third points Absorber has serpentine flow pattern.	Also available with 3/16" water white glass (139 lb -[63 kg]), and double glazed: inner Teflon FEP or Sunlite 0.025".

FLAT PLATE COLLECTORS - LIQUID

Collector Characteristics	MANUFACTURER AND LOCATION Semco Corporation Fort Lauderdale Florida 33334	Solar Energy Comp., Inc. Cocoa Florida 32922	Solar Energy Products, Inc. Gainesville Florida 32601
A Collector Panel: Model Name/No.	Tropic Sun TF-40 (105)	FFBCCS-30	CA33-1W*
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	49.0" [1244 mm] 121.0" [3073 mm] 3.5" [89 mm]		47.75" [1213 mm] 97.75" [2483 mm] 2.75" [70 mm] (double: 3.31")
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	48.875" [1241 mm] 120.9375" [3072 mm] 3.375" [86 mm]	38.0625" [967 mm] 120.875" [3070 mm] 3.75" [95 mm]	
D Gross Area of Panel (ft^2) [m^2]	41.05 ft^2 [3.81 m^2]	31.96 ft^2 [2.97 m^2]	32.41 ft^2 [3.01 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Tempered low-iron glass 1/8" [3.2 mm]	Kalwall Sunlite Prem.II FRP 0.025" [0.64 mm]	Temp. water-white gl. 46.0" [1168 mm] 96.0" [2438 mm] 3/16" [4.8 mm]
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]	46.875" [1191 mm] 116.625" [2962 mm]	[920 mm] [2.932 mm]	
H Net Aperture Area (ft^2) [m^2]	37.96 ft^2 [3.53 m^2]	29.03 ft^2 [2.70 m^2]	29.93 ft^2 [2.78 m^2]
I Aperture as % of Gross Area	92.5%	90.8%	92.3%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	0.010" copperplate with 0.5"ø tubes @ 4" cs.	Copper tubes soldered to copper sheet	0.5" nom. copper tubes expanded into al. wings
K Projections from Collector Panel and Location			End outlet, side outlet option
L Weight of Panel Empty (lb) [kg] Full (lb) [kg]	152 lb [69 kg] 160 lb [72.5 kg]	89.7 lb [40.7 kg]	179 lb [81.2 kg]
M Comments/Remarks:	Model FP40-3; information for TF40 similar to data for FP40-7. Cover plate has 4 panels, with alum. mullions.	Enclosure has fibergl. bottom and fiberglass over wood frame.	*Double glazed model CA33-2W; additional weight 83 lb [37.6 kg]

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Solar Energy Products, Inc. Gainesville Florida 32601	Solar-Eye Products, Inc. Fort Lauderdale Florida 33309	Solar Heater Manufacturer Lake Worth Florida 33460
A Collector Panel: Model Name/No.	SC19-1W*	R-200A (31)	Model SHM-10
B Listed Panel Dimensions: Width (in) [mm]	35.75" [908 mm]	48.375" [1229 mm]	
Length (in) [mm]	77.75" [1975 mm]	94.625" [2403 mm]	
Depth (in) [mm]	4.5" [114 mm] (Double: 5.06")	3.3125" [84 mm]	
C Measured Panel Dimensions: Width (in) [mm]		48.5" [1232 mm]	48.45" [1231 mm]
Length (in) [mm]		95.25" [2419 mm]	120.3125" [3056 mm]
Depth (in) [mm]		3.4375" [87 mm]	4.1" [104 mm]
D Gross Area of Panel (ft^2) [m^2]	19.26 ft^2 [1.79 m^2]	31.07 ft^2 [2.89 m^2]	40.49 ft^2 [3.76 m^2]
E Coordinating Dimensions: Width (in) [mm]	36.0" [914 mm]		
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions:	Temp. water-white glass	Kalwall Sunlite Prem. FRP	Kalwall Sunlite PremII FRP
Width (in) [mm]	34.0" [864 mm]	48.0" [1219 mm]	48.0" [1219 mm]
Length (in) [mm]	76.0" [1930 mm]	94.0" [2388 mm]	120.0" [3048 mm]
Thickness (in) [mm]	1/8" [3.2 mm]	0.040" [1.0 mm]-3 lights	0.040" [1.0 mm]
G Net Aperture Dimensions Width (in) [mm]		46.375" [1178 mm]	[1184 mm]
Length (in) [mm]		91.125" [2315 mm]	[3007 mm]
H Net Aperture Area (ft^2) [m^2]	17.38 ft^2 [1.61 m^2]	29.35 ft^2 [2.73 m^2]	38.26 ft^2 [3.55 m^2]
I Aperture as % of Gross Area	90.2%	94.5%	94.5%
J Absorber Material(s) and Size Width (in) [mm]		Copper 0.010" plate w. serpentine 0.75" tube	Copper 0.010" plate w. 0.75" I.D. copper tube
Length (in) [mm]		90.0" serpentine	
K Projections from Collector Panel and Location	End outlets	Side inlet/outlet, 2.0" [50 mm] projection	
L Weight of Panel Empty (lb) [kg]	113 lb [51.3 kg]	75 lb [34 kg]	136 lb [61.6 kg]
Full (lb) [kg]			
M Comments/Remarks:	*Double glazed model SC19-2W; additional weight 37 lb [16.8 kg].	Also tested at FSEC, but with differing dimensions. Long dimension can be vertical or horizontal. Has special mounting frame.	Serpentine flow pattern 3/4" glazing supports

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Solar Innovations, Inc. Lakeland Florida 33801	Solar Innovations, Inc. Lakeland Florida 33801	Solar Innovations, Inc. Lakeland Florida 33801
A Collector Panel: Model Name/No.	Model SC-400 (SC-300)(59)	Model SC-200	Model SC-107
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	34.64" [880 mm] 96.14" [2442 mm] 2.85" [72 mm]	22.64" [575 mm] 96.14" [2442 mm] 2.85" [72 mm]	40.64" [1032 mm] 96.14" [2442 mm] 2.85" [72 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]		22.64" [575 mm] 96.25" [2445 mm] 2.85" [72 mm]	40.75" [1035 mm] 96.3" [2446 mm] 2.85" [72 mm]
D Gross Area of Panel (ft^2) [m^2]	23.13 ft^2 [2.15 m^2]	15.13 ft^2 [1.41 m^2]	27.25 ft^2 [2.53 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Kalwall Sunlite Prem.II FRP 0.040" [1.0 mm]	Kalwall Sunlite Prem.II FRP 0.040" [1.0 mm]	Kalwall Sunlite Prem.II FRP 0.040" [1.0 mm]
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]	33.25" [845 mm] Drwg. 94.75" [2407 mm] "	[540 mm] [2410 mm]	[1000 mm] [2411 mm]
H Net Aperture Area (ft^2) [m^2]	21.88 ft^2 [2.03 m^2]	14.01 ft^2 [1.30 m^2]	25.95 ft^2 [2.41 m^2]
I Aperture as % of Gross Area		92.6%	95.2%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	Copper Rollbond	Copper Rollbond (Olin Brass) [560 mm] [2438 mm]	Copper tube with alum. fins mech. crimped [997 mm] [2360 mm]
K Projections from Collector Panel and Location			
L Weight of Panel Empty (lb) [kg] Full (lb) [kg]	84 lb [38.1 kg]	65 lb [29.5 kg]	67 lb [30.4 kg]
M Comments/Remarks:	SC-300 has Aluminum Rollbond absorber instead of copper. Weight reduction 13 lb [6 kg]		

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Solar Development, Inc. Riviera Beach Florida 33404	Solarkit of Florida, Inc. Tampa Florida 33612	Solar Products Sun-Tank, Inc. Miami Florida 33150
A Collector Panel: Model Name/No.	SD-5	SQ 15-1 (112)	Model 300
B Listed Panel Dimensions: Width (in) [mm]	24.0" [610 mm]	36.0" [914 mm]	36.0" [914 mm]
Length (in) [mm]	120.0" [3048 mm]	60.0" [1524 mm]	78.0" [1981 mm]
Depth (in) [mm]		3.5" [89 mm]	3.0" [76 mm]
C Measured Panel Dimensions: Width (in) [mm]	24.6" [625 mm]	36.0" [914 mm]	36.0" [915 mm]
Length (in) [mm]	120.375" [3058 mm]	60.0" [1524 mm]	78.125" [1984 mm]
Depth (in) [mm]	3.45" [88 mm]	3.5" [89 mm]	3.15" [80 mm]
D Gross Area of Panel (ft^2) [m^2]	20.57 ft^2 [1.91 m^2]	15.0 ft^2 [1.39 m^2]	19.54 ft^2 [1.82 m^2]
E Coordinating Dimensions: Width (in) [mm]			
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm]	Kalwall Sunlite Prem.II FRP	Herculite temp.safety gl.	Kalwall Sunlite Prem.II
Length (in) [mm]			
Thickness (in) [mm]	0.025" [0.64 mm]	1/8" [3.2 mm]	0.040" [1.0 mm]
G Net Aperture Dimensions Width (in) [mm]	[573 mm]	34.25" [870 mm]	[875 mm]
Length (in) [mm]	[3006 mm]	58.25" [1480 mm]	[1872 mm]
H Net Aperture Area (ft^2) [m^2]	18.60 ft^2 [1.73 m^2]	13.85 ft^2 [1.29 m^2]	17.63 ft^2 [1.64 m^2]
I Aperture as % of Gross Area	90.4%	92.4%	90.2%
J Absorber Material(s) and Size Width (in) [mm]	Copper tube soldered to copper sheet	0.008" coppersheet with 0.375"ø copper tube	Copper tube 0.5"I.D. pressed into galv.st. 34.25" [870 mm]
Length (in) [mm]			73.75" [1873 mm]
K Projections from Collector Panel and Location		Al. mounting legs with 2" standoff, 2"x2"x1/8" Inlet/outlet, 4.0"	1.0"ø header pipes at sides
L Weight of Panel Empty (lb) [kg]	50 lb [22.7 kg]	50 lb [22.7 kg]	82 lb [37.3 kg]
Full (lb) [kg]			
M Comments/Remarks:	Can be manufactured with double glazing.	Serpentine flow pattern Fastener centerlines: width 38.35" [972 mm], length 58.375" [1483 mm]	

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Solar Products Sun-Tank, Inc. Miami Florida 33150	Solar Systems by Sun Dance, Inc Miami Lakes Florida 33014	Solar Systems by Sun Dance, Inc. Miami Lakes Florida 33014
A Collector Panel: Model Name/No.	Sun-Tank 300A (112)	Model 1-13-P (106)	Model 1-10-D
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	40.0" [1016 mm] 88.0" [2235 mm] 3.0" [76 mm]	48.0" [1219 mm] 191.0" [4851 mm]	48.0" [1219 mm] 147.0" [3734 mm] 3.0" [76 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	40.25" [1022 mm] 88.125" [2238 mm] 3.25" [83 mm]	48.375" [1229 mm] 190.0" [4826 mm] 3.25" [83 mm]	48.425" [1230 mm] 147.125" [3737 mm] 3.0" [76 mm]
D Gross Area of Panel (ft^2) [m^2]	24.63 ft^2 [2.29 m^2]	63.83 ft^2 [5.93 m^2]	49.48 ft^2 [4.60 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Kalwall Sunlite Prem.II FRP 0.040" [1.0 mm]	Kalwall Sunlite Prem.II FRP 0.040" [1.0 mm]	Kalwall Sunlite Prem.II FRP 0.040" [1.0 mm]
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]	38.5" [978 mm] 83.25" [2115 mm] 3 panels		[1195 mm] [3324 mm]
H Net Aperture Area (ft^2) [m^2]	22.26 ft^2 [2.07 m^2]		42.75 ft^2 [3.97 m^2]
I Aperture as % of Gross Area	90.4%		86.4%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	22 gauge galv. steel with 0.5" I.D. circulat'n pipes	36 gauge copper tooling foil with 7/8"O.D. tubes	Copper tube 0.75" soldered to 36 gauge sheet [1219 mm] [3734 mm]
K Projections from Collector Panel and Location	Case has 0.75" lip on 4 sides. 2.0"projection of manifold at sides	Inlet/outlet approx. 4" at narrow end, 0.875"ø	Inlet/outlet at narrow side
L Weight of Panel Empty (lb) [kg] Full (lb) [kg]	100 lb [45.4 kg]	210 lb [95.3 kg]	152 lb [68.8 kg]
M Comments/Remarks:	Earlier model 300 differs in dimensions.	Serpentine flow pattern Other Collector models: #8, 118" long; #9, 132"; #10, 147"; #11, 162"; and, #12, 176" long.	Serpentine flow pattern 24 gauge galv. sheet steel enclosure.

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Travco., Inc. Tallahassee Florida 32301	Unit Electri Control,Inc. Maitland Florida 32751	Universal 100 Solar En. Systems, Southern Lighting Manuf. Co. Orlando Florida 32803
A Collector Panel: Model Name/No.	Model Mark II	Sol-Ray 1-6-50M (53)	Model 410 BG
B Listed Panel Dimensions: Width (in) [mm]	30.0" [762 mm]	35.25" [895 mm]	48.5" [1232 mm]
Length (in) [mm]	90.0" [2286 mm]	77.25" [1962 mm]	120.5" [3061 mm]
Depth (in) [mm]	2.50" [64 mm]	2.6875" [68 mm]	
C Measured Panel Dimensions: Width (in) [mm]	29.9375" [760 mm]	35.25" [895 mm]	48.875" [1241 mm]
Length (in) [mm]	90.16" [2290 mm]	77.375" [1965 mm]	120.9" [3071 mm]
Depth (in) [mm]	2.75" [70 mm]	2.8125" [71 mm]	7.1" [180 mm]*
D Gross Area of Panel (ft^2) [m^2]	18.73 ft^2 [1.74 m^2]	18.94 ft^2 [1.76 m^2]	41.02 ft^2 [3.81 m^2]
E Coordinating Dimensions: Width (in) [mm]	30.0" [762 mm]		
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions:	Kalwall Sunlite Prem.II FRP	Tru-temp clear glass	Temp. glass--2 pieces
Width (in) [mm]			48.0" [1219 mm]
Length (in) [mm]			2 x 60.0" [1524 mm]
Thickness (in) [mm]	0.025" [0.64 mm]	3/16" [4.8 mm]	3/16" [4.8 mm]
G Net Aperture Dimensions Width (in) [mm]	28.75" [730 mm]	33.25" [845 mm]	[1195 mm]
Length (in) [mm]	[2258 mm]	75.25" [1911 mm]	[3000 mm]
H Net Aperture Area (ft^2) [m^2]	17.74 ft^2 [1.65 m^2]	17.38 ft^2 [1.61 m^2]	[3.585 m^2]
I Aperture as % of Gross Area	94.7%	91.8%	94.0%
J Absorber Material(s) and Size Width (in) [mm]	Copper tube bonded to al. sheet 28.75" [730 mm]	0.016" copper plate with 5/8"O.D. copper tube 33.0" [838 mm]	Copper tube soldered to copper sheet
Length (in) [mm]	88.575" [2250 mm]	75.0" [1905 mm]	
K Projections from Collector Panel and Location	5/8"O.D. copper tubes at narrow end	1/2" inlet/outlet at sides	1/2" inlet/outlet at narrow end
L Weight of Panel Empty (lb) [kg]	39.2 lb [17.8 kg]	91.5 lb [41.5 kg]	143 lb [64.8 kg]
Full (lb) [kg]			
M Comments/Remarks:	Can be used with long dimension horizontally or vertically. Serpentine flow pattern.	Parallel flow pattern. Length of housing 77.125"	Serpentine flow pattern *Includes support legs 1.5" x 1.5" x 3/16" welded to case 25" from corners.

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Wilcox Manuf. Corporat'n Clearwater Florida 33565	National Solar Supply Atlanta Georgia 30318	Wallace Co. Gainesville Georgia 30501
A Collector Panel: Model Name/No.	SC 8000 (159)	NSS-3476 (7)[w]	1208C (116)
B Listed Panel Dimensions: Width (in) [mm]	48.0" [1219 mm]	34.25" [870 mm]	36.0" [914 mm]
Length (in) [mm]	96.0" [2438 mm]	76.25" [1937 mm]	78.0" [1981 mm]
Depth (in) [mm]			4.25" [108 mm]
C Measured Panel Dimensions: Width (in) [mm]	48.5" [1232 mm]		36.25" [921 mm]
Length (in) [mm]	93.3125" [2320 mm]		78.375" [1991 mm]
Depth (in) [mm]	5.25" [133 mm]		4.5" [114 mm]
D Gross Area of Panel (ft^2) [m^2]	31.43 ft^2 [2.92 m^2]	18.14 ft^2 [1.68 m^2]	19.73 ft^2 [1.83 m^2]
E Coordinating Dimensions: Width (in) [mm]			
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm]	Kalwall Prem.II--FRP	Tempered glass- double	Tempered glass
Length (in) [mm]			
Thickness (in) [mm]	0.040" [1.0 mm]	2 x 1/8" [2 x 3.2 mm]	1/8" [3.2 mm]
G Net Aperture Dimensions Width (in) [mm]	46.5" [1181 mm]		33.25" [845 mm]
Length (in) [mm]	91.3125" [2319 mm]		75.375" [1914 mm]
H Net Aperture Area (ft^2) [m^2]	29.49 ft^2 [2.74 m^2]	17.0 ft^2	17.40 ft^2 [1.62 m^2]
I Aperture as % of Gross Area	93.8%	93.7% ?	88.2%
J Absorber Material(s) and Size Width (in) [mm]	Copper tube with 0.025" alum. fins	Copper plate with tubes 0.0216"	16 oz. with 0.25"I.D. copper tubes
Length (in) [mm]			
K Projections from Collector Panel and Location	0.875"O.D. tubes, 2.0" [50 mm] from top & bottom		Inlet/outlet, 1.5" at sides
L Weight of Panel Empty (lb) [kg]		105 lb [47.6 kg]	98 lb [44.5 kg]
Full (lb) [kg]			
M Comments/Remarks:	Also: SC 8000D, double glazed, w. inner cover of 0.025" Kalwall Prem.II All alum. case with 2 mullion supports for cover plate.	Collector has aluminum case.	Parallel flow pattern

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Hawaiian Sunpak Corp'n. Kahului, Maui Hawaii 96732	La-Wela-Wai Koloa Hawaii 96756	Maui Economic Opportunity, Inc. Kahului, Maui Hawaii 96732
A Collector Panel: Model Name/No.	HS 101 (100)	L-W-W-1 (36)	Meo-Maui Type 4x8 (12)
B Listed Panel Dimensions: Width (in) [mm]	38.5" [978 mm]	48.0" [1219 mm]	
Length (in) [mm]	100.5" [2553 mm]	96.0" [2438 mm]	
Depth (in) [mm]		2.7" [69 mm]	
C Measured Panel Dimensions: Width (in) [mm]	39.0" [991 mm] var.	48.625" [1235 mm]	48.125" [1222 mm]
Length (in) [mm]	100.75" [2559 mm] "	96.625" [2454 mm]	96.125" [2442 mm]
Depth (in) [mm]	8.75" [222 mm]*	2.875" [73 mm]	4.0" [102 mm]
D Gross Area of Panel (ft^2) [m^2]	27.29 ft^2 [2.53 m^2]	32.62 ft^2 [3.03 m^2]	32.13 ft^2 [2.98 m^2]
E Coordinating Dimensions: Width (in) [mm]			
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm]	*Plexiglas, domed shape	0.004" Tedlar	Filon Reinf. fiberglass 5 oz/ft^2
Length (in) [mm]			
Thickness (in) [mm]	3/16" [4.8 mm]	0.004" [0.1 mm]	
G Net Aperture Dimensions Width (in) [mm]	34.375" [873 mm]	46.5625" [1183 mm]	45.125" [1146 mm]
Length (in) [mm]	96.125" [2442 mm]	94.5" [2400 mm]	93.125" [2365 mm]
H Net Aperture Area (ft^2) [m^2]	22.95 ft^2 [2.13 m^2]	30.56 ft^2 [2.84 m^2]	29.18 ft^2 [2.71 m^2]
I Aperture as % of Gross Area	84.0%	93.7%	90.8%
J Absorber Material(s) and Size Width (in) [mm]	16 oz Olin copper 34.0" [964 mm]	0.5" copper tubes with 6.0" wide al. fin extr.	Copper sheet w. 0.5"I.D copper tube 43.625" [1108 mm]
Length (in) [mm]	96.0" [2438 mm]		98.0" [2489 mm]
K Projections from Collector Panel and Location		5/8"O.D. copper pipes, 2.0" [50 mm] narrow end	5/8"O.D. copper pipe, 4.0" [100 mm] narrow end
L Weight of Panel Empty (lb) [kg]	5 lb/ft^2	70 lb [31.8 kg]	
Full (lb) [kg]			
M Comments/Remarks:	*Frame height 2.25" [57 mm]	Limited to use in Hawaii and non-freezing climates. Serpentine flow pattern. Cover has 3 L-shaped supports @ equal centers, 0.75".	Limited to use in the State of Hawaii Serpentine flow pattern Wood frame with 0.5" plywood back. 2 cover supports 1/8" x 1"

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Precision Industries Honululu Hawaii 96817	Chamberlain Manuf. Corp* Elmhurst Illinois 60128	Chamberlain Manuf. Corp.* Elmhurst Illinois 60128
A Collector Panel: Model Name/No.	AP-18 (133)	#711101 (3x7) (125)	#711102 (3x8)
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	46.0" [1168 mm] 76.0" [1930 mm]	36.25" [921 mm] 84.25" [2140 mm] 4.375" [111 mm]	36.25" [921 mm] 96.25" [2445 mm] 4.375" [111 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	46.375" [1178 mm] 76.5" [1943 mm] 4.3125" [110 mm]	36.25" [921 mm] 84.375" [2143 mm] 4.375" [111 mm]	
D Gross Area of Panel (ft^2) [m^2]	24.64 ft^2 [2.29 m^2]	21.24 ft^2 [1.97 m^2]	24.23 ft^2 [2.25 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	ASG Sunadex temp. glass 3/16" [4.8 mm]	Low-iron temp. glass 1/8" [3.2 mm]	Low-iron temp. glass 1/8" [3.2 mm]
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]	43.75" [1111 mm] 73.75" [1873 mm]	33.75" [857 mm] 81.875" [2080 mm]	
H Net Aperture Area (ft^2) [m^2]	22.41 ft^2 [2.08 m^2]	19.19 ft^2 [1.78 m^2]	21.96 ft^2 [2.04 m^2]
I Aperture as % of Gross Area	90.9%	90.5%	90.6%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]		2 sheets 20 gauge M.S. stitchwelded & expanded	2 sheets 20 gauge M.S. stitchwelded & expanded
K Projections from Collector Panel and Location	0.875"ø tubes projecting approx. 3.0" at sides	Inlet/outlet holes flush with collector	Inlet/outlet holes flush with collector
L Weight of Panel Empty (lb) [kg] Full (lb) [kg]		160 lb [72.6 kg]	190 lb [86.2 kg]
M Comments/Remarks:		*Acquired by Solaron Corporation, Denver, Co. Also avail. with copper abs. plates. Double gl. model 711301: 5.0625" thick, 190 lb [86.2 kg]	*Acquired by Solaron Corporation, Denver, Co. Also avail. with copper abs. plates. Double gl. model 711302: 5.0625" thick, 225 lb [102 kg]

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Lennox Industries, Inc.* Marshalltown Iowa	Sun-Pac Incorporated Pineville Louisiana 71360	Dumont Industries Monmouth Maine 04259
A Collector Panel: Model Name/No.	LSC 18-1	Sun*Miser SS (158)	SA-4 (9)
B Listed Panel Dimensions: Width (in) [mm]	36.0" [914 mm] Nom.	36.0" [914 mm]	35.5" [902 mm]
Length (in) [mm]	72.0" [1829 mm] "	98.0" [2489 mm	77.5" [1969 mm]
Depth (in) [mm]	6.5" [165 mm]	2.5" - 3.5" [64 - 89 mm]	4.0" [102 mm]
C Measured Panel Dimensions: Width (in) [mm]	35.875" [911 mm]	36.00" [914 mm]	35.5" [902 mm]
Length (in) [mm]	71.8125" [1824 mm]**	97.875" [2486 mm]	77.625" [1972 mm]
Depth (in) [mm]	6.25" [159 mm]	2.75" [70 mm]	4.0" [102 mm]
D Gross Area of Panel (ft^2) [m^2]	17.89 ft^2 [1.66 m^2]	24.47 ft^2 [2.27 m^2]	19.14 ft^2 [1.78 m^2]
E Coordinating Dimensions: Width (in) [mm]	36.0" [914 mm]		36.0" [914 mm]
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions:	Low-iron tempered glass	ASG Sunadex glass	Low-iron temp. glass
Width (in) [mm]			
Length (in) [mm]			
Thickness (in) [mm]	2 x 1/8" [2 x 3.2 mm]	3/16" [4.8 mm]	2 x 1/8" [2 x 3.2 mm]
G Net Aperture Dimensions Width (in) [mm]		33.50" [851 mm]	33.125" [841 mm]
Length (in) [mm]		95.50" [2426 mm]	75.125" [1908 mm]
H Net Aperture Area (ft^2) [m^2]		22.22 ft^2 [2.06 m^2]	17.28 ft^2 [1.61 m^2]
I Aperture as % of Gross Area		90.9%	90.3%
J Absorber Material(s) and Size Width (in) [mm]	0.035" steel plate with 1/4" copper flow tubes	Olin Brass Roll-bond 9121--0.010" copper*	Olin Roll-bond alum. absorber 0.060"
Length (in) [mm]			
K Projections from Collector Panel and Location		Inlet/outlet at back of collector, 2.375" [60 mm]	Inlet/outlet at narrow end, 1.0" [25 mm]
L Weight of Panel Empty (lb) [kg]	123 lb [55.8 kg]	100 lb [45 kg] ±10%	120 lb [54.4 kg]
Full (lb) [kg]			
M Comments/Remarks:	*Joint venture with Honeywell Inc., Energy Resources Center, Minneapolis 58143 **Overall length with mounting brackets: 72.06" [1830 mm]	Fiberglass enclosure with 3/4" [19 mm] lip all round. *Alternative absorber Olin #9171.	Can be made with Roll-bond copper absorber plate. Tolerances on size: ± 1/16"

FLAT PLATE COLLECTORS - LIQUID

Collector Characteristics	MANUFACTURER AND LOCATION Shape, Symmetry & Sun Biddeford Maine 04005	Mega Engineering Silver Spring Maryland 20903	Acorn Sunwave Energy Systems, Acorn Structures, Inc. Concord Massachusetts 01742
A Collector Panel: Model Name/No.	DHW-3 (69)	MFPC-40Z-G	410-Sunwave (32)
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	32.0" [813 mm] 96.0" [2438 mm]	48.0" [1219 mm] 96.0" [2438 mm]	48.0" [1219 mm] 120.0" [3048 mm] 5.0" [127 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	32.0625" [814 mm] 96.25" [2445 mm] 5.125" [130 mm]		47.5" [1207 mm] 120.5" [3060 mm] 5.375" [137 mm]
D Gross Area of Panel (ft^2) [m^2]	21.43 ft^2 [1.99 m^2]	32.0 ft^2 [2.97 m^2]	39.75 ft^2 [3.69 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Polycarbonate 0.060" + Kalwall FRP 0.025"	ASG water-white glass	Tedlar covered FRP 0.037" [0.94 mm]
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]	29.3125" [745 mm] 92.375" [2346 mm]		44.25" [1124 mm] 117.25" [2978 mm]
H Net Aperture Area (ft^2) [m^2]	18.80 ft^2 [1.75 m^2]	29.7 ft^2 [2.76 m^2]	36.03 ft^2 [3.35 m^2]
I Aperture as % of Gross Area	87.7%	92.8%	90.6%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	Aluminum 0.060"	0.060" steel plate with bonded copper tubes*	Copper tube 3/8" on copper absorber plate* 44.125" [1120 mm] 114.0" [2896 mm]
K Projections from Collector Panel and Location	Alum. pipes 0.5"O.D. at back	Inlet, bottom right; outlet, top left.	Inlet/outlet one side.
L Weight of Panel Empty (lb) [kg] Full (lb) [kg]	75 lb [34 kg]	120 lb [54.4 kg]	125 lb [56.7 kg]
M Comments/Remarks:	6" - 8" standoff from roof recommended.	*Technical information also lists absorber pl. as 0.040" aluminum. Serpentine flow pattern	* Also 0.020" aluminum plate absorber. Douglas fir or redwood frame with 3/8" plywood back. Mounting side-by-side @ 48" [1220 mm]cs.

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Columbia Chase Solar Energy Division Holbrook Massachusetts 02343	Daystar Corporation Burlington Massachusetts 01803	Daystar Corporation Burlington Massachusetts 01803
A Collector Panel: Model Name/No.	Redi-Mount#3494-1 (63)	Daystar 21-B (50)	Daystar 21-C
B Listed Panel Dimensions: Width (in) [mm]	44.0" [1118 mm]	44.5" [1130 mm]	44.5" [1130 mm]
Length (in) [mm]	107.0" [2718 mm]	80.75" [2051 mm]	72.75" [1848 mm]
Depth (in) [mm]	4.5" [114 mm]	5.25" [133 mm]	5.25" [133 mm]
C Measured Panel Dimensions: Width (in) [mm]	43.375" [1102 mm]	44.75" [1137 mm]	44.7" [1135 mm] FSEC
Length (in) [mm]	107.125" [2720 mm]	81.0" [2057 mm]	72.85" [1850 mm] "
Depth (in) [mm]	5.00" [127 mm]	5.25" [133 mm]	5.125" [130 mm] "
D Gross Area of Panel (ft^2) [m^2]	32.27 ft^2 [3.00 m^2]	25.17 ft^2 [2.34 m^2]	22.60 ft^2 [2.10 m^2] "
E Coordinating Dimensions: Width (in) [mm]		48.0" [1220 mm]	48.0" [1220 mm]
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm]	Filon 0.045"-6 oz/ft^2 FRP	ASG Low-iron temp. glass with folded polymer heat trap	ASG Low-iron temp. glass w. folded polymer heat trap
Length (in) [mm]			[1085 mm] FSEC
Thickness (in) [mm]	0.045" [1.15 mm]	3/16" [4.8 mm]	3/16" [4.8 mm]
G Net Aperture Dimensions Width (in) [mm]	34.5" [876 mm]	42.875" [1089 mm]	[1085 mm] FSEC
Length (in) [mm]	97.625" [2480 mm]	71.0625" [1805 mm]	[1805 mm]
H Net Aperture Area (ft^2) [m^2]	23.39 ft^2 [2.17 m^2]	21.16 ft^2 [1.97 m^2]	21.08 ft^2 [1.96 m^2]
I Aperture as % of Gross Area	72.5%	84.1% (Reduced % due to heat rejector)	93.3%
J Absorber Material(s) and Size Width (in) [mm]	Kennecott copper absorber tube-in-sheet construct. 34.0" [864 mm]	0.020" Copper plate with parallel copper tubes	0.020" Copper plate w. parallel copper tubes* 42.0" [1067 mm]
Length (in) [mm]	94.0" [2388 mm]		70.0" [1778 mm]
K Projections from Collector Panel and Location	Inlet/outlet top & bottom	Projection of upper and lower manifolds 2.5"	
L Weight of Panel Empty (lb) [kg]	62 lb [28.1 kg]	148.6 lb [67.4 kg]	121 lb [54.9 kg]
Full (lb) [kg]	65 lb [29.5 kg]		
M Comments/Remarks:	Also Model 3494-2 with Teflon film as inner glazing. Fiberglass 0.110" one-piece molded frame with 1.5" [38 mm] mounting flange.	Has built-in limiter assembly at top, 8.0" wide [203 mm wide]. 4" [100 mm] min. vertical spacing; 3.5" [90 mm] min. horiz. spacing	*An earlier model had serpentine flow pattern

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Dixon Energy Systems, Inc. Hadley Massachusetts 01035	Sunsav, Inc. Tewksbury Massachusetts 01876	Solar Research Division Refrigeration Res., Inc. Brighton Michigan 48116
A Collector Panel: Model Name/No.	Yankee (Recess and Surface Mount)	SS-6 (117)	#5849 Hydronic (62)
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	34.5" [876 mm] 76.5" [1943 mm]	41.5" [1054 mm] 96.75" [2457 mm] 8.5" [216 mm]	21.375" [543 mm] 73.625" [1864 mm] 4.125" [105 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]		41.875" [1064 mm] 97.125" [2467 mm] 8.75" [222 mm]	21.5" [546 mm] 73.875" [1876 mm] 4.25" [108 mm]
D Gross Area of Panel (ft^2) [m^2]	18.33 ft^2 [1.70 m^2]	28.24 ft^2 [2.62 m^2]	11.03 ft^2 [1.02 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]	36.0" [914 mm]		
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	ASG Sunadex --double gl.	Tempered glass 1/8" [3.2 mm]	DuPont Tedlar PVF film 0.004" [0.1 mm]- 2 x
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]		33.6875" [856 mm] 87.25" [2216 mm]*	20.125" [511 mm] 72.25" [1835 mm]*
H Net Aperture Area (ft^2) [m^2]	17.5 ft^2 [1.63 m^2]	20.41 ft^2 [1.90 m^2]	10.10 ft^2 [0.94 m^2]*
I Aperture as % of Gross Area	95.5%		91.5%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	0.016" copper plate with 3/8" tube grid @ 5.5" cs.	2 copper Roll-bond absorbers side-by-side	Steel absorber 0.024" with 3/8" O.D. st. tubes 20.0" [508 mm]
K Projections from Collector Panel and Location			Inlet/outlet threads flush with frame
L Weight of Panel Empty (lb) [kg] Full (lb) [kg]	160 lb [72.6 kg] 163 lb [74 kg]	148 lb [67.1] ??	41 lb [18.6 kg]
M Comments/Remarks:	Recess mount (rough framing size): 34.75" x 76.75" [883 mm x 1949 mm] Surface mount: 36.75" x 78.75" [933 mm x 2000 mm]	*Center support for glazing, 1-5/8" [41 mm] wide.	Can be built up in batteries of collectors i.e. box of 4: 85" wide [2060 mm] *Less three supports for Tedlar cover plate

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Northern Solar Power Co. Moorhead Minnesota 56560	Solergy Co. Minneapolis Minnesota 55428	Calmac Manuf. Corp'n. Englewood New Jersey 07631
A Collector Panel: Model Name/No.	Sun Save	SG-100 (146)	Sunmat SM-1032 (8)
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	37.0" [940 mm] 99.0" [2515 mm] 5.0" [127 mm]	35.25" [895 mm] 97.375 [2473 mm] 3.0" [76 mm]	50.0" [1270 mm]* 98.0" [2489 mm]* 3.5" [89 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]		35.25" [895 mm] var. 97.375" [2473 mm] " 3.0" [76 mm]	50.0625" [1272 mm] 98.125" [2492 mm] 3.75" [95 mm]
D Gross Area of Panel (ft^2) [m^2]	25.44 ft^2 [2.36 m^2]	23.84 ft^2 [2.21 m^2]	34.11 ft^2 [3.17 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Sunlite Premium II FRP + Teflon FEP 0.001" 0.040" [1.0 mm]	Kalwall Sunlite Prem.II FRP 0.040" [1.0 mm]	Kalwall Sunlite Prem.II FRP 0.040" [1.0 mm]
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]		33.375" [848 mm] 95.50" [2426 mm]	45.625" [1159 mm] 93.50" [2375 mm]
H Net Aperture Area (ft^2) [m^2]	22.5 ft^2 [2.09 m^2] ?	22.13 ft^2 [2.06 m^2]	29.62 ft^2 [2.75 m^2]
I Aperture as % of Gross Area	88.4%	92.8%	86.8%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	Aluminum Roll-bond 0.040"	Olin Aluminum 0.060" Collector panel 34.0" [864 mm] 96.0" [2438 mm]	Alum. sheet 0.002" with 5/16" O.D. EPDM tubing
K Projections from Collector Panel and Location		0.75"O.D. inlet/outlet pipes top & bottom, 2.25"	1" flange around total perimeter. Inlet/outlet connections same side.
L Weight of Panel Empty (lb) [kg] Full (lb) [kg]	70 lb [31.8 kg]	60 lb [27.2 kg] approx	80 lb [36.3 kg]
M Comments/Remarks:	For retrofit installation with mounting brackets.	Also available with 0.040" copper Solar-bond absorber plate, empty weight 85 lb [38.5 kg]: Model SG-200.	*Includes 1" flange all round--net case 48" x 96" Collector can be built in sizes up to 300" [7620 mm] to lower installation and plumbing costs.

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	E.S.P., Inc. Medford New Jersey 07631	Solar Energy Systems, Inc. Cherry Hill New Jersey 08003	Solar USA, Inc. Berkeley Heights New Jersey 07922
A Collector Panel: Model Name/No.	#E.S.P.-SCW (136)	Sunerator 100	Model 28 S (25)
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	48.0" [1219 mm] 120.0" [3048 mm]	35.0" [889 mm] 77.0" [1956 mm] 6.5" [165 mm]	24.0" [610 mm] 96.0" [2438 mm] 3.5" [89 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	47.875" [1216 mm] 120.0" [3048 mm]		24.0625" [611 mm] 96.125" [2442 mm] 3.75" [95 mm]
D Gross Area of Panel (ft^2) [m^2]	39.90 ft^2 [3.71 m^2]	18.72 ft^2 [1.74 m^2]	16.06 ft^2 [1.49 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Fiberglass 0.040" [1.0 mm]	Low-iron glass	Double Kalwall cover 0.025" and 0.040"
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]	44.625" [1133 mm] 116.75" [2965 mm]		22.875" [581 mm] 94.875" [2410 mm]
H Net Aperture Area (ft^2) [m^2]	36.18 ft^2 [3.36 m^2]	17.2 ft^2 [1.60 m^2]	15.07 ft^2]1.40 m^2]
I Aperture as % of Gross Area	90.7%	91.9%	93.8%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	Copper 0.010" with Type L copper tubes	Copper Solar-Bond 0.040"	2 sheets of copper 16oz 0.022"; flow in between
K Projections from Collector Panel and Location	Inlet/outlet top & bottom		Connections at sides by neoprene hose
L Weight of Panel Empty (lb) [kg] Full (lb) [kg]	2.5 lb/ft^2 approx.	105 lb [47.6 kg]	
M Comments/Remarks:		Optional double glazing	Other model 37 S: 36" x 84" x 3.5" [914 mm x 2134 mmx 89 mm]. Alum. frame with angle for mounting at each end

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Bio-Energy Systems, Inc. Spring Glen New York 12483	Grumman Energy Systems, Inc. Ronkonkoma New York 11779	Grumman Energy Systems, Inc. Ronkonkoma New York 11779
A Collector Panel: Model Name/No.	SolaRoll TG-32 (122)	Sunstream 60A (2)	Sunstream 60F (2)
B Listed Panel Dimensions: Width (in) [mm]	44.0" [1118 mm]	40.75" [1035 mm]	40.75" [1035 mm]
Length (in) [mm]	96.0" [2438 mm]	110.5" [2807 mm]	110.5" [2807 mm]
Depth (in) [mm]	4.75" [121 mm]	9.0" [229 mm] max.	9.0" [229 mm] max.
C Measured Panel Dimensions: Width (in) [mm]	45.25" [1150 mm] var.	40.625" [1032 mm]	40.625" [1032 mm]
Length (in) [mm]	96.875" [2461 mm] "	110.0" [2794 mm]	110.0" [2794 mm]
Depth (in) [mm]	5.00" [127 mm]	2.5 - 9.0" [64 - 229 mm]	2.25 - 9.0" [57 - 229 mm]
D Gross Area of Panel (ft^2) [m^2]	30.44 ft^2 [2.83 m^2]	31.03 ft^2 [2.88 m^2]*	31.03 ft^2 [2.88 m^2]*
E Coordinating Dimensions: Width (in) [mm]			
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm]	ASG Sunadex + 0.001" Teflon	Curved Acrylic Cover	Curved Acrylic Cover
Length (in) [mm]			
Thickness (in) [mm]	3/16" [4.8 mm]	1/8" [3.2 mm]	1/8" [3.2 mm]
G Net Aperture Dimensions Width (in) [mm]	41.4375" [1053 mm]	32.625" [829 mm]	32.625" [829 mm]
Length (in) [mm]	92.9375" [2361 mm]	105.625" [2683 mm] var.	107.0" [2718 mm]
H Net Aperture Area (ft^2) [m^2]	26.74 ft^2 [2.48 m^2]	24.58 ft^2 [2.28 m^2]*	24.58 ft^2 [2.28 m^2]*
I Aperture as % of Gross Area	87.6%	79.2%	79.2%
J Absorber Material(s) and Size Width (in) [mm]	EPDM rubber 0.310" with 3/16"I.D. flow passages	0.060" Al. Roll-bond 2	Finplank Al. extrusion 0.065" with copper tube 34.5" [876 mm]
Length (in) [mm]			105.5" [2680 mm]
K Projections from Collector Panel and Location	1.125"O.D. copper inlet/ outlet at sides	Inlet/outlet at ends	Inlet/outlet at ends
L Weight of Panel Empty (lb) [kg]	145 lb [65.8 kg]	87 lb [39.5 kg]	122.5 lb [55.6 kg]
Full (lb) [kg]			
M Comments/Remarks:	Monolothic black elastomer absorber Collectors are site-built.	*Stated in manufacturers literature. Actual measurements are less. Separate support system available. Recommended roof standoff 5.5".	*Stated in manufacturers literature. Actual measurements are less. Mounting on roof or on separate support rack.

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics			Grumman Energy Systems, Inc. Ronkonkoma New York 11779	Grumman Energy Systems, Inc. Ronkonkoma New York 11779	Grumman Energy Systems, Inc. Ronkonkoma New York 11779
A	Collector Panel: Model Name/No.		Sunstream 100F (2)	Sunstream 100-2 (2)	Sunstream 200F (2)
B	Listed Panel Dimensions:	Width (in) [mm]	36.75" [933 mm]*	36.75" [933 mm]	36.75" [933 mm]
		Length (in) [mm]	108.75" [2762 mm]*	108.75" [2762 mm]	108.75" [2762 mm]
		Depth (in) [mm]	5.46875" [139 mm]	4.44" [113 mm]	5.25" [133 mm]
C	Measured Panel Dimensions:	Width (in) [mm]	36.8125" [935 mm]	36.75" [933 mm]	
		Length (in) [mm]	108.75" [2762 mm]	108.8125" [2764 mm]	
		Depth (in) [mm]	5.5" [140 mm]	5.5" [140 mm]	
D	Gross Area of Panel (ft^2) [m^2]		27.80 ft^2 [2.58 m^2]*	27.77 ft^2 [2.58 m^2]	27.75 ft^2 [2.58 m^2]
E	Coordinating Dimensions:	Width (in) [mm]			
		Length (in) [mm]			
F	Cover Plate Material(s) and Dimensions:	Width (in) [mm]	Sunadex temp. low-iron gl.	Temp. Sunadex water-wh.	Double temp. Sunadex
		Length (in) [mm]			
		Thickness (in) [mm]	3/16" [4.8 mm]	3/16" [4.8 mm]	2 x 3/16" [2 x 4.8 mm]
G	Net Aperture Dimensions	Width (in) [mm]	32.25" [819 mm]	32.75" [832 mm]	32.75" [832 mm]
		Length (in) [mm]	104.1875" [2646 mm]	104.6875' [2659 mm]	104.8125'[2662 mm]
H	Net Aperture Area (ft^2) [m^2]		23.82 ft^2 [2.21 m^2]*	23.82 ft^2 [2.21 m^2]	23.82 ft^2 [2.21 m^2]
I	Aperture as % of Gross Area		85.8%	85.8%	85.8%
J	Absorber Material(s) and Size	Width (in) [mm]	Finplank alum. extrusion with 3/8"O.D. copper tubes 34.5" [876 mm]	0.040" Olin copper Roll bond expanded sheet 34.375" [873 mm]	Finplank 0.065" alum. extr. with copper tubes
		Length (in) [mm]	104.12" [2645 mm]	104.125" [2645 mm]	
K	Projections from Collector Panel and Location		Inlet/outlet at ends diag. opposite	Inlet/outlet at ends overall length 109"	Inlet/outlet at ends
L	Weight of Panel	Empty (lb) [kg]	180 lb [81.6 kg]	159 lb [72.1 kg]	235 lb [106.6 kg]
		Full (lb) [kg]	184 lb [83.5 kg]		239 lb [108.4 kg]
M	Comments/Remarks:		*Stated in manufacturers literature. Measured dimensions/areas differ. Can be integrated into waterproof roofs or walls. *1" projecting flange all round--box 34.75" x 106.75"	Pan dimensions 34.75" x 106.75" [883 x 2711 mm] with 1" [25 mm] flange all round.	

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Grumman Energy Systems, Inc. Ronkonkoma New York 11779	Grumman Energy Systems, Inc. Ronkonkoma New York 11779	Prima Industries, Inc. Deer Park New York 11729
A Collector Panel: Model Name/No.	Sunstream 321 Model 300 Model 400	Sunstream 332 Model 300 Model 400	Model 2001
B Listed Panel Dimensions: Width (in) [mm]	35.0" [889 mm]	47.75" [1213 mm]	34.5" [876 mm]
Length (in) [mm]	84.0" [2134 mm]	96.0" [2438 mm]	97.0" [2464 mm]
Depth (in) [mm]	2.75"/3.45" [70 mm/88 mm]	2.75"/3.45" [70 mm/88 mm]	
C Measured Panel Dimensions: Width (in) [mm]			
Length (in) [mm]			
Depth (in) [mm]			
D Gross Area of Panel (ft^2) [m^2]	20.42 ft^2 [1.90 m^2]	31.83 ft^2 [2.96 m^2]	23.24 ft^2 [2.16 m^2]
E Coordinating Dimensions: Width (in) [mm]			
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions:	Solatex tempered glass	Solatex tempered glass	ASG temp. water white
Width (in) [mm]			
Length (in) [mm]			
Thickness (in) [mm]	1/8" [3.2 mm] 300:single 400:double	3/16" [4.8 mm] 300:single 400:double	
G Net Aperture Dimensions Width (in) [mm]			
Length (in) [mm]			
H Net Aperture Area (ft^2) [m^2]	18.9 ft^2 [1.76 m^2]	30.0 ft^2 [2.79 m^2]	22.66 ft^2 [2.11 m^2] ?
I Aperture as % of Gross Area	92.6%	94.2%	97.5%
J Absorber Material(s) and Size Width (in) [mm]	Cu-Plank Absorber plate with 8 1/4" copper tubes	Cu-Plank absorber plate with 11 1/4" copper tubes	0.040" copper Solar-bond w. integral tubes
Length (in) [mm]			
K Projections from Collector Panel and Location			
L Weight of Panel Empty (lb) [kg]	Model 300 Model 400	Model 300 Model 400	123 lb [55.8 kg]
Full (lb) [kg]	79 lb [36 kg] 126 lb [57 kg]	119 lb [54 kg] 210 lb [95 kg]	
M Comments/Remarks:	Model 300: single glazed Model 400: double glazed Collectors can be built in other sizes. Parallel or rack mounting	Model 300: single glazed Model 400: double glazed Collectors can be built in other sizes. Parallel or rack mounting	3/4" redwood frame

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Revere Solar and Architectural Products, Inc. Rome New York 13440	Solarom of North America Inc. Westbury New York 11590	Sunray Solar Heat Inc. Brooklyn New York 11205
A Collector Panel: Model Name/No.	Sun-Aid 132:single gl. 211:double gl.	SCO-200 (42)	SR-4-1 (144)
B Listed Panel Dimensions: Width (in) [mm]	35.0" [889 mm]	38.375" [975 mm] Drwg.	35.875" [911 mm]
Length (in) [mm]	77.0" [1956 mm]	78.0" [1980 mm] "	77.875" [1978 mm]
Depth (in) [mm]	4.5" [114 mm]	3.0" [75 mm] "	3.7" [94 mm]
C Measured Panel Dimensions: Width (in) [mm]	34.875" [886 mm]	38.125" [968 mm]	35.875" [911 mm]
Length (in) [mm]	76.875" [1953 mm]	78.0625" [1983 mm]	75.875" [1927 mm]
Depth (in) [mm]	4.5" [114 mm]	3.125" [80 mm]	3.6875" [94 mm]
D Gross Area of Panel (ft^2) [m^2]	18.62 ft^2 [1.73 m^2]	20.67 ft^2 [1.92 m^2]	18.90 ft^2 [1.76 m^2]
E Coordinating Dimensions: Width (in) [mm]			
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm]	Temp. water-white glass	Plate glass 2 mm thick	ASG Sunadex temp. glass low-iron shatter res.
Length (in) [mm]			
Thickness (in) [mm]	1/8" [3.2 mm] 132:single 211:double	0.080" [2 mm]	5/32" [4.0 mm]
G Net Aperture Dimensions Width (in) [mm]		36.25" [920 mm]	33.25" [845 mm]
Length (in) [mm]		73.625" [1870 mm] (net)	73.125" [1857 mm]
H Net Aperture Area (ft^2) [m^2]	17.2 ft^2 [1.60 m^2]	18.53 ft^2 [1.72 m^2]	16.88 ft^2 [1.57 m^2]
I Aperture as % of Gross Area	92.4%	89.7%	89.3%
J Absorber Material(s) and Size Width (in) [mm]	0.032" copper plate with 1/4" tubes @5.5" cs.	Alum. alloy plate 0.022" with copper tubes	0.010" copper plate w. 8-3/8"O.D. copper tubes
Length (in) [mm]			
K Projections from Collector Panel and Location	Flush 1/2" female threaded connections at ends	Supply and return connections 2.5" at side	Inlet/outlet at ends
L Weight of Panel Empty (lb) [kg]	Model 132 Model 211	80 lb [36 kg]	80 lb [36 kg] approx.
Full (lb) [kg]	90 lb [41 kg] 120 lb [54.4 kg]		
M Comments/Remarks:	Adjustable brackets for roof installation. Aluminum frame and back.	Specifications in U.S. customary and metric units. 2 support strips for cover at 26" cs. Affiliated with Solarom Indust., Haifa, Israel	

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Air Comfort, Inc. Raleigh North Carolina	LOF Solar Energy Systems [Libbey-Owens-Ford] Toledo Ohio 43605	LOF Solar Energy Systems [Libbey-Owens-Ford] Toledo Ohio 43605
A Collector Panel: Model Name/No.	Whitol V	SunPanel 121 (96)	SunPanel 221 Double glazed
B Listed Panel Dimensions: Width (in) [mm]	36.25" [921 mm] Drwg.	36.0" [914 mm]	36.0" [914 mm]
Length (in) [mm]	90.25" [2292 mm] "	84.0" [2134 mm]	84.0" [2134 mm]
Depth (in) [mm]	4.785" [122 mm] "	4.75" [121 mm]	5.625" [143 mm]
C Measured Panel Dimensions: Width (in) [mm]	36.4375" [925 mm]	36.00" [914 mm]	
Length (in) [mm]	90.5625" [2300 mm]	84.0625" [2135 mm]	
Depth (in) [mm]	4.95" [126 mm]	4.75" [121 mm]	
D Gross Area of Panel (ft^2) [m^2]	22.92 ft^2 [2.13 m^2]	21.02 ft^2 [1.95 m^2]	21.0 ft^2 [1.95 m^2]
E Coordinating Dimensions: Width (in) [mm]		36.25" [920 mm]*	As for Model 121
Length (in) [mm]		89.00" [2260 mm]**	
F Cover Plate Material(s) and Dimensions: Width (in) [mm]	Sunlite Prem.II FRP	Single, low-iron glass selective coating	Double, low-iron temp. glass w. selective c.
Length (in) [mm]			
Thickness (in) [mm]	0.040" [1.0 mm]	1/8" [3.2 mm]	2 x 1/8" [2 x 3.2 mm]
G Net Aperture Dimensions Width (in) [mm]	33.875" [860 mm]	33.75" [857 mm]	As for Model 121
Length (in) [mm]	88.0" [2235 mm]*	81.75" [2076 mm]	
H Net Aperture Area (ft^2) [m^2]	20.69 ft^2 [1.92 m^2]	19.16 ft^2 [1.78 m^2]	19.16 ft^2 [1.78 m^2]
I Aperture as % of Gross Area	90.3%	91.2%	91.2%
J Absorber Material(s) and Size Width (in) [mm]	12 oz/ft^2 copper sheet with soldered copper tubes [880 mm]	Copper 0.017" with all copper soldered tubes	Copper 0.021" with all copper soldered tubes
Length (in) [mm]	[2130 mm]		
K Projections from Collector Panel and Location	Inlet/outlet at ends	Inlet/outlet 1.75" top and bottom, ±0.375"	Inlet/outlet 1.75" top and bottom, ±0.375"
L Weight of Panel Empty (lb) [kg]	87 lb [39.4 kg]	90 lb [40.8 kg]	130 lb [59 kg]
Full (lb) [kg]		110 lb [50 kg]	150 lb [68 kg]
M Comments/Remarks:	*2 1/2" x 1/2" angles @ 30" cs. to support cover reduce aperture area.	*1/8" to 1/4" clearance for thermal expansion. ** 4" to 6" (nominal 5") space required for fittings and mounting. Other Model No.s in 100 Series: different glass	200 Model series indicates double glazed collectors. Mounting by means of 4 6" x 1.25" hold-down handles at ends.

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	O.S. Solar Energy, Inc. [Hatic Heating, R. & A.C.] Milford Ohio 45150	Solartec, Inc. Salem Ohio 44460	Solartec, Inc. Salem Ohio 44460
A Collector Panel: Model Name/No.	Model OS-1 (68)	Model #101 (60)	Model #102
B Listed Panel Dimensions: Width (in) [mm]	24.0" [610 mm]	23.875" [606 mm]	23.875" [606 mm]
Length (in) [mm]	96.0" [2438 mm]	95.875" [2435 mm]	47.875" [1216 mm]
Depth (in) [mm]	4.0" [102 mm]	3.5" [89 mm]	3.5" [89 mm]
C Measured Panel Dimensions: Width (in) [mm]	24.125" [613 mm]	24.0" [610 mm]	
Length (in) [mm]	96.25" [2445 mm]	96.125" [2442 mm]	
Depth (in) [mm]	4.25" [108 mm]	3.5" [89 mm]	
D Gross Area of Panel (ft^2) [m^2]	16.13 ft^2 [1.50 m^2]	16.02 ft^2 [1.48 m^2]	7.94 ft^2 [0.74 m^2]
E Coordinating Dimensions: Width (in) [mm]		Designed for installation @ 24" [610 mm] cs.	Designed for installation @ 24" [610 mm] cs.
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm]	2-Kalite #03105	Plexiglas, U.V.T or Tempered low-iron glass	Plexiglas (std)-Others optional
Length (in) [mm]			
Thickness (in) [mm]	2-0.040" [2 x 1.0 mm]	1/8" [3.2 mm]	1/8" [3.2 mm]
G Net Aperture Dimensions Width (in) [mm]	22.5625" [573 mm]	20.5" [521 mm]	
Length (in) [mm]	94.6875" [2405 mm]	86.25" [2191 mm]**	
H Net Aperture Area (ft^2) [m^2]	14.84 ft^2 [1.38 m^2]	12.28 ft^2 [1.14 m^2]	
I Aperture as % of Gross Area	92.0%	76.7%	
J Absorber Material(s) and Size Width (in) [mm]	0.040" Rollbond Alloy 122 copper	0.0055" copper foil with 0.5" copper tubes (8)	
Length (in) [mm]		Area: 11.87 ft^2	
K Projections from Collector Panel and Location	Inlet/outlet 4" [100 mm] at ends (optinal, sides)	Inlet/outlet at ends	
L Weight of Panel Empty (lb) [kg]	68 lb [30.8 kg]	58 lb [26.3 kg]*	24 lb [10.9 kg]
Full (lb) [kg]		64.3 lb [29.2 kg]	27.2 lb [12.3 kg]
M Comments/Remarks:		* Varies with cover pl. material. ** 3 panels, 28.75" between supports	Limited information available only.

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	The Stolle Corporation Sidney Ohio 45365	Sun Life Solar Products Clackamas Oregon 97015	Ametek, Inc.; Power Systems Group Hatfield Pennsylvania 19440
A Collector Panel: Model Name/No.	Type AS Ribbed or Smooth	SP-100 (49)	SunJammer D-189[c] (110)
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	50.5" [1283 mm] 103.625" [2632 mm] 4.125" [105 mm]	35.75" [908 mm] 77.75" [1975 mm]	37.75" [959 mm] 97.75" [2483 mm] 5.44" [138 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	51.0" [1296 mm] 102.85" [2612 mm] 5.9" [150 mm]	35.75" [908 mm] 77.75" [1975 mm] 3.75" [95 mm]	37.75" [959 mm] 97.75" [2483 mm] 5.4" [137 mm]
D Gross Area of Panel (ft^2) [m^2]	36.44 ft^2 [3.39 m^2]	19.3 ft^2 [1.79 m^2]	25.63 ft^2 [2.38 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]			38.5" min. [978 mm]
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Double-strength glass 9/64" [3.5 mm]	Tempered window glass 1/8" [3.2 mm]	ASG water-wh. temp. gl. 36.0" [914 mm] 96.0" [2438 mm] 3/16" [4.8 mm]
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]	[1244 mm] [2491 mm]*	33.50" [851 mm] 75.50" [1912 mm]	34.75" [883 mm] 94.875" [2410 mm]
H Net Aperture Area (ft^2) [m^2]	33.35 ft^2 [3.10 m^2]	17.56 ft^2 [1.63 m^2]	22.90 ft^2 [2.13 m^2]
I Aperture as % of Gross Area	91.5%	91.0%	89.4%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	Copper tube press fit to ext. alum. fin sheet t&g [1223 mm] [2540 mm]	0.021" copper with 3/8" O.D. copper tubing	Olin Roll-bond 0.040" copper 34.0" [864 mm] 94.0" [2388 mm]
K Projections from Collector Panel and Location	Inlet/outlet one side	Mounting brackets at ends, 1" [25 mm]; Inlet/outlet both sides	Inlet/outlet at ends 104.5" [2654 mm] overall
L Weight of Panel Empty (lb) [kg] Full (lb) [kg]	Ribbed 85.2 kg Smooth 80.5 kg	100 lb [45.3 kg]	155 lb [70.3 kg]
M Comments/Remarks:	Serpentine flow pattern *Includes 3 glazing supports 7/8" wide at equal cs.	Alum. frame and back Glazing is carried within its own frame. Optional double glazing Wt. 130 lb [59 kg]	Variuos mounting alternatives for direct or steel rack mounting.

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Ametek, Inc.; Power Systems Group Ivyland Pennsylvania 18974	PPG Industries, Inc. Pittsburgh Pennsylvania 15222	PPG Industries, Inc. Pittsburgh Pennsylvania 15222
A Collector Panel: Model Name/No.	SunJammer Model D-222	Model C-224 (126)	Model C-524 (126)
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	37.75" [959 mm] 99.75" [2534 mm] 5.44" [138 mm]	35.375" [899 mm] 77.375" [1965 mm] 5.094" [129 mm]	35.375" [899 mm] 77.375" [1965 mm] 5.656" [144 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]		35.375" [899 mm] 77.375" [1965 mm] 5.125" [130 mm]	35.50" [902 mm] 77.375" [1965 mm] 5.625" [143 mm]
D Gross Area of Panel (ft^2) [m^2]	26.15 ft^2 [2.43 m^2]	19.01 ft^2 [1.77 m^2]	19.01 ft^2 [1.77 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]	38.5" min. [978 mm] min.		
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Sunadex low-iron temp. gl. 3/16" [4.8 mm]	Temp. water-white glass 1/8" [3.2 mm]	Double temp. w-wh. gl. 2 x 1/8" [2 x 3.2 mm]
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]		33.0625" [840 mm] 75.00" [1905 mm]	33.125" [841 mm] 75.125" [1908 mm]
H Net Aperture Area (ft^2) [m^2]		17.22 ft^2 [1.60 m^2]	17.28 ft^2 [1.61 m^2]
I Aperture as % of Gross Area		90.6%	90.9%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	Olin Solar-Bond 0.040" copper absorber	Copper tubes soldered to 0.021" copper plate	Copper tubes soldered to 0.021" copper plate
K Projections from Collector Panel and Location	Inlet/outlet at ends; overall length 103.875"	1.125" copper inlet/outlet at sides, 1.75" each	1.125" copper inlet/outlet at sides
L Weight of Panel Empty (lb) [kg] Full (lb) [kg]	160 lb [72.6 kg] 165 lb [74.8 kg]	124 lb [56.2 kg]	152 lb [69 kg]
M Comments/Remarks:	Universal mounting for a variety of mounting designs.	Model Type II C114 is similar	Similar models TYPE II C514 and C512

MANUFACTURER AND LOCATION

	Collector Characteristics	Simons Solar Systems, Inc. Mechanicsburg Pennsylvania 17055	Sunearth Solar Products Corp. Montgomeryville Pennsylvania 18936	Vulcan Solar Industr., Inc. Pawtucket Rhode Island 02860
A	Collector Panel: Model Name/No.	WCA (65)	Model 3597ADGFB (19)	#CC-1F/G Sunline (120)
B	Listed Panel Dimensions: Width (in) [mm]	24.0" [610 mm]	32.44" [824 mm] Drwg.	43.1875" [1097 mm]
	Length (in) [mm]	96.0" [2438 mm]	97.44" [2475 mm] "	107.0" [2718 mm]
	Depth (in) [mm]	3.875" [98 mm]	4.25" [108 mm] "	3.125" [79 mm]
C	Measured Panel Dimensions: Width (in) [mm]	24.25" [616 mm]	32.375" [822 mm]	43.125" [1095 mm]
	Length (in) [mm]	96.0" [2438 mm]	97.4375" [2373 mm]	107.0" [2718 mm]
	Depth (in) [mm]	3.875" [98 mm]	4.0625" [103 mm]	3.375" [86 mm]
D	Gross Area of Panel (ft^2) [m^2]	16.17 ft^2 [1.50 m^2]	21.91 ft^2 [2.04 m^2]	32.04 ft^2 [2.98 m^2]
E	Coordinating Dimensions: Width (in) [mm]	24.0" [610 mm]		
	Length (in) [mm]			
F	Cover Plate Material(s) and Dimensions: Width (in) [mm]	Kalwall Sunlite Prem.II double gl.	Acrylic outer 0.080" Teflon inner 0.001"	Filon FRP 6 oz.
	Length (in) [mm]			
	Thickness (in) [mm]	0.040" [1.0 mm]	0.080" [2.0 mm]	0.040" [1.0 mm]
G	Net Aperture Dimensions Width (in) [mm]	22.0" [559 mm]	29.625" [752 mm] var.	34.4375" [875 mm]
	Length (in) [mm]	93.5" [2375 mm]*net	94.625" [2403 mm]* "	98.125" [2492 mm]
H	Net Aperture Area (ft^2) [m^2]	14.28 ft^2 [1.33 m^2]	19.47 ft^2 [1.81 m^2]	23.47 ft^2 [2.18 m^2]
I	Aperture as % of Gross Area	88.3%	88.9%	73.3%
J	Absorber Material(s) and Size	Olin Roll-Bond copper	Alum. extr. fin 0.060" with 3/8"O.D. copper tubes	0.010" copper tubes bonded to 0.010" sheet
	Width (in) [mm]	22.0" [559 mm]		34.0" [864 mm]
	Length (in) [mm]	94.0" [2388 mm]		94.0" [2388 mm]
K	Projections from Collector Panel and Location	Inlet/outlet connections at end.	Copper inlet/outlet tubes at sides, 0.75"	Full perimeter mounting flange. Center inlet/ at ends.
L	Weight of Panel Empty (lb) [kg]	80 lb [36.3 kg]	73 lb [33.1 kg]	60 lb [27.2 kg]
	Full (lb) [kg]		75 lb [34 kg]	63 lb [28.6 kg]
M	Comments/Remarks:	*3 supports for cover plate @ 23.375" cs., 3/8" wide, subtracted from aperture dimension.	*Cover plate has 3 5/8" wide glazing supports Designed for northeast United States. Overall manifold width is 32.0" [813 mm]	Fiberglass molded frame with full perimeter mounting glange.

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	State Industries, Inc. Ashland City Tennessee 37015	Alternative Energy Resources, Inc. El Paso Texas 79925	American Solar King Corp'n. Waco Texas 76710
A Collector Panel: Model Name/No.	SC1-4 (98)	Solar-Rey Model #3	DG-15 (41)
B Listed Panel Dimensions: Width (in) [mm]	39.5" [1003 mm]	36.25" [921 mm]	36.25" [921 mm]
Length (in) [mm]	99.5" [2527 mm]	96.0" [2438 mm]	94.25" [2394 mm]
Depth (in) [mm]	7.5" [190 mm] ?	4.5" [114 mm]	3.5" [89 mm]
C Measured Panel Dimensions: Width (in) [mm]	40.0" [1016 mm]*		36.125" [918 mm]
Length (in) [mm]	99.5" [2527 mm]*		94.375" [2397 mm]
Depth (in) [mm]	4.0" [102 mm]*		3.5" [89 mm]
D Gross Area of Panel (ft^2) [m^2]	27.64 ft^2 [2.57 m^2]	24.17 ft^2 [2.25 m^2]	23.68 ft^2 [2.20 m^2]
E Coordinating Dimensions: Width (in) [mm]			
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm]	Outer: 0.040" Acrylic FRP Inner: 0.001" Teflon FEP	Double temp. w.wh. gl.	Water-wh. crystal temp. double glazing
Length (in) [mm]			
Thickness (in) [mm]	0.040" [1.0 mm]	2 x 1/8" [2 x 3.2 mm]	2 x 5/32" [2 x 4.0 mm]
G Net Aperture Dimensions Width (in) [mm]	38.25" [972 mm]		33.0" [838 mm]
Length (in) [mm]	97.75" [2483 mm]		91.0" [2311 mm]
H Net Aperture Area (ft^2) [m^2]	25.96 ft^2 [2.41 m^2]		20.85 ft^2 [1.94 m^2]
I Aperture as % of Gross Area	93.9%		88.0%
J Absorber Material(s) and Size Width (in) [mm]	Two 20gauge cold-rolled steel sheets-inflated 35.0" [889 mm]	Two sheets 22gauge cold-rolled steel-expanded	Roll-bond copper abs. plate
Length (in) [mm]	96.0" [2438 mm]		
K Projections from Collector Panel and Location	Inlet/outlet & sensor at back. Mounting legs at back.		Inlet/outlet pipes at ends near corner, 2.75"
L Weight of Panel Empty (lb) [kg]	150 lb [68 kg]		190 lb [86.2 kg]
Full (lb) [kg]			195 lb [88.5 kg]
M Comments/Remarks:	*Also tested at FSEC, but with different dimensions Outer cover profiled Panel frame and housing in steel; 38.25" x 98.25" at top.	Galv. steel outer box	Redwood frame and plywood back, 3/8".

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Cole Solar Systems, Inc. Austin Texas 78745	Cole Solar Systems, Inc. Austin Texas 78745	Cole Solar Systems, Inc. Austin Texas 78745
A Collector Panel: Model Name/No.	406 A & AT	408 A & AT	410 A & AT (26)
B Listed Panel Dimensions: Width (in) [mm]	48.25" [1226 mm]	48.25" [1226 mm]	48.25" [1226 mm]
Length (in) [mm]	72.25" [1835 mm]	96.25" [2445 mm]	120.25" [3054 mm]
Depth (in) [mm]	5.375" [137 mm] Model A 6.625" [168 mm] Model AT	5.375" [137 mm] A 6.625" [168 mm] AT	5.375" [137 mm] A 6.625" [168 mm] AT
C Measured Panel Dimensions: Width (in) [mm]			48.125" [1222 mm] AT
Length (in) [mm]			120.125" [3051 mm] AT
Depth (in) [mm]			6.625" [168 mm] AT
D Gross Area of Panel (ft^2) [m^2]	24.21 ft^2 [2.25 m^2]	32.25 ft^2 [3.00 m^2]	40.15 ft^2 [3.73 m^2]
E Coordinating Dimensions: Width (in) [mm]			
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm]	Outer: Acrylic Single A Inner: Teflon Double AT	Outer: Acrylic Inner: Teflon FEP 0.001"	Outer: Acrylic Inner: Teflon FEP 0.001"
Length (in) [mm]			
Thickness (in) [mm]	1/8" [3.2 mm] Single or double	1/8" [3.2 mm]	1/8" [3.2 mm]
G Net Aperture Dimensions Width (in) [mm]			46.625" [1184 mm]
Length (in) [mm]			116.625" [2962 mm]*
H Net Aperture Area (ft^2) [m^2]	22.4 ft^2 [2.08 m^2]*	30.0 ft^2 [2.79 m^2]*	37.76 ft^2 [3.51 m^2]
I Aperture as % of Gross Area	92.5%	93.0%	94.0%
J Absorber Material(s) and Size Width (in) [mm]	0.040" alum. spotwelded around 3/8"O.D. copper t	0.040" alum. spotwelded around 3/8" copper tubes	0.040" alum. spotwelded around 3/8" copper tubes
Length (in) [mm]			
K Projections from Collector Panel and Location	Support brackets at 48" cs	Support brackets 64" or 72".	Support brackets 72" or 80".
L Weight of Panel Empty (lb) [kg]	Model A 95 lb* [43 kg] Model AT 100 lb* [45.4 kg]	Model A 125 lb* [56.7 kg] Model AT 130 lb* [59 kg]	Model A 140 lb [63.5 kg] Model AT 150 lb [68 kg]
Full (lb) [kg]			
M Comments/Remarks:	*Data taken from manuf. literature Support brackets for rear mounting.	*Data taken from manuf. literature Support brackets for mounting.	24 gauge galv. steel frame, and support brackets designed to fit 16" or 24" rafter spacings. *118.125 aperture less two 0.75" al. supports

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Heliosystems Corporation Dallas Texas 75204	Northrup, Inc. Hutchins Texas 75141	Solar Enterprises, Inc. Arlington Texas 76012
A Collector Panel: Model Name/No.	MT 200 C (43)	FP1G or FP2G	Slimliner (152)
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	37.3" [947 mm] Drwg. 99.25" [2521 mm] " 6.0" [152 mm] "	37.25" [946 mm] 103.56" [2630 mm] 5.5" [140 mm]	48.0" [1219 mm] 96.0" [2438 mm] 2.5" [64 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	37.375" [949 mm] var. 99.25" [2521 mm] " 6.0" [152 mm]		48.5" [1232 mm] 96.5" [2451 mm] 2.75" [70 mm]
D Gross Area of Panel (ft^2) [m^2]	25.76 ft^2 [2.39 m^2]	26.79 ft^2 [2.49 m^2]	32.50 ft^2 [3.02 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Outer: Kalwall Sunlite Inner: 0.003" Teflon 0.040" [1.0 mm] (outer)	ASG Tru-Temp low-iron [FP1G]*	
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]	35.0" [889 mm]* 95.25" [2419 mm]*	32.125" [816 mm]** 98.375" [2499 mm]**	46.25" [1175 mm] 92.00" [2337 mm]*
H Net Aperture Area (ft^2) [m^2]	23.15 ft^2 [2.15 m^2]	21.95 ft^2 [2.04 m^2]	29.55 ft^2 [2.75 m^2]
I Aperture as % of Gross Area	90.0%	82.0%	90.9%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	Copper Olin Solar-Bond, FS 9121-0.040"	Extr. aluminum plate w. 1/2"O.D. copper tubes	
K Projections from Collector Panel and Location	Inlet/outlet diagonally opposite at short ends	Inlet/outlet at ends	Inlet/outlet at sides
L Weight of Panel Empty (lb) [kg] Full (lb) [kg]		180 lb [81.6 kg]	75 lb [34 kg]
M Comments/Remarks:	*Uses 3/8" Al. H-channel supports for cover plate One-piece fiberglass-reinforced plastic molded housing (3/16" - 1/4" thick) with sloping sides.	*FP2G has inner glazing of Teflon FEP **Provided in technical literature; not verified by measurement. 20-gauge galv. steel case.	*Uses 3 alum. supports 0.75" wide across collector cover.

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Solar Alternative, Inc. Brattleboro Vermont 05301	InterTechnology/Solar Corporation Warrenton Virginia 22186	Reynolds Metals Co. Richmond Virginia 23261
A Collector Panel: Model Name/No.	Solite Model III (17)	Mark V (23)	Model 1502 (16)
B Listed Panel Dimensions: Width (in) [mm]	24.125" [613 mm]	35.375" [899 mm]	47.75" [1213 mm]
Length (in) [mm]	100.125" [2543 mm]*	77.375" [1965 mm]	95.75" [2432 mm]
Depth (in) [mm]	5.0" [127 mm]	5.25" [133 mm]	3.375" [86 mm]
C Measured Panel Dimensions: Width (in) [mm]	24.0625" [611 mm]	35.625" [905 mm]	47.5625" [1208 mm]
Length (in) [mm]	100.5" [2553 mm]*	77.625" [1972 mm]	95.5625" [2427 mm]
Depth (in) [mm]	5.0625" [129 mm]	4.50" [114 mm] ?	3.375" [86 mm]
D Gross Area of Panel (ft^2) [m^2]	16.79 ft^2 [1.56 m^2]	19.20 ft^2 [1.78 m^2]	31.56 ft^2 [2.93 m^2]
E Coordinating Dimensions: Width (in) [mm]	24.0" [610 mm]	36.0" [914 mm]*	
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions:	Kalwall Sunlite Prem.II	Temp. low-iron glass	UV treated polyester Martin UVX
Width (in) [mm]	24.75" [629 mm]		
Length (in) [mm]	100.25" [2546 mm]		
Thickness (in) [mm]	0.040" [1.0 mm]	1/8" [3.2 mm]	0.007" [0.18 mm]
G Net Aperture Dimensions Width (in) [mm]	23.25" [590 mm]	33.00" [838 mm]	44.75" [1137 mm]
Length (in) [mm]	94.5" [2400 mm] net	75.00" [1905 mm]	91.75" [2330 mm]*
H Net Aperture Area (ft^2) [m^2]	15.26 ft^2 [1.42 m^2]	17.19 ft^2 [1.60 m^2]	28.51 ft^2 [2.65 m^2]
I Aperture as % of Gross Area	91.0%	89.5%	90.3%
J Absorber Material(s) and Size Width (in) [mm]	Kennecott Model 1A Terra-Light 0.0027" copper abs. 22.0" [559 mm]	Ext. alum fins 0.060" with 8 copper tubes	Extruded alum. finned collector plate & tubes
Length (in) [mm]	96.0" [2438 mm]	69.5" [1765 mm]	
K Projections from Collector Panel and Location	Inlet/outlet pipes 5/8" O.D. at ends. Mounting flange at bottom.	Inlet/outlet at long side,	Inlet/outlet at narrow end, 2.5" nom.
L Weight of Panel Empty (lb) [kg]		113 lb [51.3 kg]	64.8 lb [29.4 kg]
Full (lb) [kg]		117 lb [53 kg]	70.2 lb [31.8 kg]
M Comments/Remarks:	*Length of housing, excl. aluminum mounting flange; Overall length 104.625". Collector comes without side pieces, which are available for array edge.	Galv. 20-ga. steel fr. Also Model Mark III: 47.375" x 97.375" x 5.25" *Drawing: 35.25" x 77.25" with 0.75" space between collectors.	Models 1401, 1402 and 1501 have same size but differ in glazing and/or tube diameter. *Glazing support at center. Horizontal mounting.

FLAT PLATE COLLECTORS - LIQUID

MANUFACTURER AND LOCATION

Collector Characteristics	Reynolds Metals Company Richmond Virginia 23261	Solar One Ltd. Virginia Beach Virginia 23452	Ecotope Group Seattle Washington 98112
A Collector Panel: Model Name/No.	Model 1452 (16)	Sol 16 (24)	Ecotope Rain (95)
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	47.75" [1213 mm] 143.75" [3651 mm] 3.375" [86 mm]	24.0" [610 mm] 97.25" [2470 mm] (2 x 8) 3.625" [92 mm]	48.0" [1219 mm] 96.0" [2438 mm] 5.875" [149 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	47.5625" [1208 mm] 143.5625' [3646 mm] 4.125" [105 mm]	24.375" [619 mm] 97.375" [2473 mm] 3.625" [92 mm]	48.875" [1267 mm]*Cover 97.875" [2486 mm]*Cover 7.25" [184 mm]
D Gross Area of Panel (ft^2) [m^2]	47.42 ft^2 [4.40 m^2]	16.48 ft^2 [1.53 m^2]	33.9 ft^2 [3.15 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	UV treated polyester + Teflon 0.001" inner 0.007" [0.18 mm]	Kalwall Sunlite Prem. II FRP 0.004" [1.0 mm]	Double-strength glass + 0.0005" Teflon film 1/8" [3.2 mm]
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]	44.6875" [1135 mm] 137.625" [3496 mm]*(net)	22.375" [568 mm] 94.625" [2403 mm]*(net)	45.875" [1165 mm] 92.375" [2346 mm]
H Net Aperture Area (ft^2) [m^2]	42.71 ft^2 [3.97 m^2]	14.70 ft^2 [1.37 m^2]	29.43 ft^2 [2.73 m^2]
I Aperture as % of Gross Area	90.1%	89.2%	86.8%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	Extr. alum. finned tubing 0.050"--one piece plate	Terra-Light absorber copper 0.003" 22.0" [559 mm] 96.0" [2438 mm]	26-ga. galv. roofing w. 0.5" copper tubes 45.0" [1143 mm] 93.0" [2362 mm]
K Projections from Collector Panel and Location	Inlet/outlet at narrow ends, 2.5" proj. nominal	Inlet/outlet at narrow ends, diagonally oppos.	Inlet/outlet at sides 3/4" copper, 3" nom.
L Weight of Panel Empty (lb) [kg] Full (lb) [kg]	97.4 lb [44.2 kg] 103 lb [46.7 kg]	29.5 lb [13.4 kg]	
M Comments/Remarks:	Similar Model 1552 with single glazing. Mounting frames available to hold one or two collectors. (Variable angle) *3 glazing supports across	Aluminum frame, with central glazing support	*Cover projects beyond case (47.875" x 96.25") **1.5" wide glazing support bar at center Workshop model.

APPENDIX 2

FLAT PLATE COLLECTORS -

AIR

FLAT PLATE COLLECTORS - AIR

MANUFACTURER AND LOCATION

Collector Characteristics	Future Systems, Inc. Lakewood Colorado 80228	SLV Solar Energy Ass'n Alamosa Colorado 81101	Solaron Corporation Denver Colorado 80222
A Collector Panel: Model Name/No.	SUN*TRAC SC-32 (88)[W]	North Collector (101)	Series 2000
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	50.0" [1270 mm] 98.0" [2489 mm] 12.0" [305 mm]	72.0" [1829 mm] 96.0" [2438 mm] 6.75" [171 mm]	36.0" [914 mm] 78.0" [1981 mm] 7.25" [184 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]		72.0" [1829 mm] 96.0" [2438 mm]	
D Gross Area of Panel (ft^2) [m^2]	34.03 ft^2 [3.16 m^2]	48.0 ft^2 [4.46 m^2]	19.5 ft^2 [1.81 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Temp. Glass double 2 x 3/16" [2 x 4.8 mm]	Kalwall 0.040" [1.0 mm]	2/Low-iron temp.glass 2 x 1/8" [2 x 3.2 mm]
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]		64.0" [1627] 3 panels 92.125" [2340 mm]	
H Net Aperture Area (ft^2) [m^2]		40.94 ft^2 [3.80 m^2]	17.4 ft^2 [1.62 m^2]
I Aperture as % of Gross Area		85.3%	89.2%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	Aluminum fin (vertical) 22.0" [559 mm] x 2 93.0" [2362 mm]	Rainlock corr. alum.	28-gauge steel
K Projections from Collector Panel and Location			
L Weight of Panel (lb) [kg]	350 lb [159 kg]		153 lb [69.4 kg]
M Comments/Remarks:	Al. fins 22" x 2.25" @ 1" cs. on fin mounting strip. Site-assembled collector	SLV = San Luis Valley Site assembly of collector.	Designed for 1 to 3 panel high arrays--internal manifolding up to 8 panels.

FLAT PLATE COLLECTORS - AIR

MANUFACTURER AND LOCATION

Collector Characteristics	Solaron Corporation Denver Colorado 80222	Sunworks, Div. of Enthone New Haven Connecticut 06508	Sunworks, Div. of Enthone New Haven Connecticut 06508
A Collector Panel: Model Name/No.	Series 3001 (82)	Air Solector (5'-4")*	Air Solector (7'-0")*
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	34.75" [883 mm] 76.75" [1949 mm] 8.06" [205 mm]	35.5" [902 mm] 64.0" [1626 mm] 4.0" [102 mm]	35.5" [902 mm] 84.0" [2134 mm] 4.0" [102 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	34.875" [886 mm] 76.875" [1953 mm] 8.75" [222 mm]		
D Gross Area of Panel (ft^2) [m^2]	18.62 ft^2 [1.73 m^2]	15.8 ft^2 [1.47 m^2]	20.7 ft^2 [1.92 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]		36.0" [914 mm]	36.0" [914 mm] 90.0" to 92.0"
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Temp. Glass 0.125" [3.2 mm]	Temp.Glass single or double glazed single: 3/16" [4.8 mm] double: 2 x 1/8" [3.2 mm]	Temp. Glass single or double glazed single: 3/16" [4.8 mm] double: 2 x 1/8" [3.2 mm]
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]			
H Net Aperture Area (ft^2) [m^2]	17.00 ft^2 [1.58 m^2]		18.96 ft^2 [1.76 m^2]
I Aperture as % of Gross Area	91.3%		91.6%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]		0.016" copper [0.4 mm]	0.016" copper [0.4 mm] 35.0" [889 mm] 82.25" [2089 mm]
K Projections from Collector Panel and Location			2.25" x 81.25" exit duct at rear, 1" proj.
L Weight of Panel (lb) [kg]	135 lb [61.2 kg]		single: 116 lb [52.6 kg] double: 143 lb [64.9 kg]
M Comments/Remarks:	Glazing unit is limiting component of collector.	Designed for surface-mounted module. *Production on request	Designed for surface-mounted module. *Production on request

FLAT PLATE COLLECTORS - AIR

MANUFACTURER AND LOCATION

Collector Characteristics	Heliodyne, Inc. Rockford Illinois 61108	BDP Systems Co. Indianapolis Indiana 46231	BDP Systems Co. Indianapo Indiana 46231
A Collector Panel: Model Name/No.	MD 732 (140)	170A/SCF ----------	Alternative Models
B Listed Panel Dimensions: Width (in) [mm]	32.0" [813 mm]	24.0" [610 mm]	24.0" [610 mm]
Length (in) [mm]	84.0" [2134 mm]	96.0" [2438 mm]	144"; 216" [3658; 5468]
Depth (in) [mm]	4.125" [105 mm]		
C Measured Panel Dimensions: Width (in) [mm]	32.0" [813 mm]		
Length (in) [mm]	84.0625" [2135 mm]		
Depth (in) [mm]	4.125" [105 mm]		
D Gross Area of Panel (ft^2) [m^2]	18.68 ft^2 [1.74 m^2]	16.0 ft^2 [1.49 m^2]	24; 36 ft^2 [2.23; 3.34]
E Coordinating Dimensions: Width (in) [mm]		24.0" cs. [610 mm cs.]	24.0" cs. [610 mm cs.]
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm]	Sunadex		
Length (in) [mm]			
Thickness (in) [mm]	1/8" [3.2 mm]		
G Net Aperture Dimensions Width (in) [mm]			
Length (in) [mm]			
H Net Aperture Area (ft^2) [m^2]	17.67 ft^2 [1.64 m^2]	14.0 ft^2 [1.30 m^2]	21; 32 ft^2 [1.95; 2.97]
I Aperture as % of Gross Area	94.6%	87.5%	87.5%; 88.9%
J Absorber Material(s) and Size Width (in) [mm]	Alum. extr. 0.060"	Corr. alum. embossed	Corr. alum. embossed
Length (in) [mm]			
K Projections from Collector Panel and Location			
L Weight of Panel (lb) [kg]	84 lb [38.1 kg]	40 lb [18.1 kg]	
M Comments/Remarks:	Integral mounting is possible.	Can be surface mounted or integrally mounted.	Can be surface mounted or integrally mounted.

FLAT PLATE COLLECTORS - AIR

MANUFACTURER AND LOCATION

Collector Characteristics	Impac Corporation Keokuk Iowa 53632	Energy Alternatives, Inc. Wichita Kansas 67209	Mid-Western Solar & Insulation Paducah Kentucky 42001
A Collector Panel: Model Name/No.	ISIS SH 3481 (104)	EA-41 (156)	Model 96* (86)
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	38.0" [965 mm] 86.0" [2184 mm] 8.0" [203 mm]	34.5" [876 mm] 96.5" [2451 mm] 5.0" [127 mm]	
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	38.125" [968 mm] 86.125" [2188 mm] 7.625" [194 mm]		150.25" [3816 mm] var. 103.25" [2629 mm] " 12.625" [321 mm] "
D Gross Area of Panel (ft^2) [m^2]	22.80 ft^2 [2.12 m^2]	23.12 ft^2 [2.15 m^2]	107.73 ft^2 [10.01 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Acrylic Modif. FRP 0.035"		ASG 3/16" double gl. 2 x 3/16" [2 x 4.8 mm]
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]		32.75" [832 mm] 95.0" [2413 mm]	134.625" [3420 mm] 94.375" [2397 mm]
H Net Aperture Area (ft^2) [m^2]	19.4 ft^2 [1.80 m^2]	21.6 ft^2 [2.0 m^2]	88.25 ft^2 [8.12 m^2]
I Aperture as % of Gross Area	85.1%	93.5%	81.9%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	Aluminum 0.003"		Aluminum 30 gauge Serpentine flow pattern
K Projections from Collector Panel and Location			
L Weight of Panel (lb) [kg]	75 lb [34.0 kg]	130 lb [59 kg]	
M Comments/Remarks:			*Original submission to DoE Collector Test Program was Model 32 (48" x 96"). Model 96 has 3 sections with an aluminum reflector for each.

FLAT PLATE COLLECTORS - AIR

MANUFACTURER AND LOCATION

Collector Characteristics	Northern Solar Power Co. Moorhead Maine 56560	DIY-SOL Inc. Marlboro Massachusetts 01752	Solafern, Ltd. Borne Massachusetts 02532
A Collector Panel: Model Name/No.	Sun-Sert	Model 36 (139)	Solafern 3012 (89)
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	14.0" [356 mm] 93.0" [2362 mm] 3.0" [76 mm]	49.5" [1257 mm] 125.25" [3181 mm] 8.0" [203 mm]	50.125" [1273 mm] 97.375" [2474 mm] 9.125" [232 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]			 9.0" [227 mm]
D Gross Area of Panel (ft^2) [m^2]	9.04 ft^2 [0.84 m^2]	43.05 ft^2 [4.00 m^2]	33.90 ft^2 [3.15 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]	16.0" [406 mm]		
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	0.025" Kalwall Sunlite II 0.001" Teflon FEP	0.040" Kalwall Prem.II 0.004" Tedlar 0.001" Teflon 100A	Tempered glass 7/32" [5.5 mm]
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]		45.5" [1156 mm] 108.75" [2762 mm]	44.75" [1137 mm] 95.0" [2413 mm]
H Net Aperture Area (ft^2) [m^2]		34.36 ft^2 [3.19 m^2]	29.52 ft^2 [2.74 m^2]
I Aperture as % of Gross Area		79.8%	87.1%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	Aluminum 22-gauge	Aluminum 0.005"	0.003" copper
K Projections from Collector Panel and Location		Inlet and outlet ports at back, 4" O.D.	Mounting Flange-edges
L Weight of Panel (lb) [kg]		61.2 lb [27.8 kg]	190 lb [86.2 kg]
M Comments/Remarks:	For installation between members at 16" cs.	Douglas fir frame, 3/4"	1" [25 mm] mounting flange on long sides for roof or rack mount. Duct former for horizontal connection of multiple collectors.

FLAT PLATE COLLECTORS - AIR

MANUFACTURER AND LOCATION

Collector Characteristics	Champion Home Builders Co. Dryden [Solar Div'n] Michigan 48428	National Energy Corp. Lakeville Minnesota 55044	West Central Missouri Rural Development Corp. Appleton City Missouri 64724
A Collector Panel: Model Name/No.	1032	HP 600 (150)[W]	SED 01 (4x8) (124)
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	48.0" [1219 mm] 96.0" [2438 mm]	36.0" [914 mm] 78.0" [1981 mm] 7.25" [184 mm]	49.5" [1257 mm] 97.25" [2470 mm] 4.5" [114 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]			49.375" [1254 mm] 97.375" [2473 mm] 5.125" [130 mm]
D Gross Area of Panel (ft^2) [m^2]	32.0 ft^2 [2.97 m^2]	19.5 ft^2 [1.81 m^2]	33.39 ft^2 [3.10 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Low-iron temp. glass 3/16" [4.8 mm]		4-oz Filon
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]			44.5" [1130 mm] 93.75" [2381 mm]
H Net Aperture Area (ft^2) [m^2]			28.97 ft^2 [2.69 m^2]
I Aperture as % of Gross Area			86.8%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	Aluminun fins, vertical		29-gauge $1^1/4$ pitch corr. galv. iron
K Projections from Collector Panel and Location			
L Weight of Panel (lb) [kg]	260 lb [118 kg]		120 lb [54.4 kg]
M Comments/Remarks:			wood frame and 3/8" plywood back

FLAT PLATE COLLECTORS - AIR

MANUFACTURER AND LOCATION

Collector Characteristics	Solar Inc. [Solar Aire Systems] Mead Nebraska 68041	Contemporary Systems, Inc. Walpole New Hampshire 03608	Solar Components Div'n Kalwall Corporation Manchester New Hampshire 03105
A Collector Panel: Model Name/No.	202 GRP Solar-Aire (91)	CSI Series V (90)	KAL-Air BB48-F (76)
B Listed Panel Dimensions: Width (in) [mm]	36.0" [914 mm]	23.875" [606 mm]	47.375" [1203 mm]
Length (in) [mm]	78.125" [1984 mm]	168.0" [4267 mm]*	95.5" [2426 mm]
Depth (in) [mm]	4.0" [102 mm]	4.0" [102 mm]	2.75" [70 mm]
C Measured Panel Dimensions: Width (in) [mm]	35.625" [905 mm]	24.0" [610 mm]	47.375" [1203 mm]
Length (in) [mm]	77.75" [1975 mm]	168.25" [4274 mm]	95.625" [2429 mm]
Depth (in) [mm]	2.875" [73 mm]	4.25" [108 mm]	2.875" [73 mm]
D Gross Area of Panel (ft^2) [m^2]	19.24 ft^2 [1.79 m^2]	28.04 ft^2 [2.60 m^2]	31.46 ft^2 [2.92 m^2]
E Coordinating Dimensions: Width (in) [mm]		24.0" cs. [610 mm cs.]	36.0" [1219 mm]
Length (in) [mm]			96.0" [2438 mm]
F Cover Plate Material(s) and Dimensions: Width (in) [mm]	Temp. clear soda lime gl.	FRP 0.040"; Teflon 0.001'	0.040" Sunlite FRP II
Length (in) [mm]			
Thickness (in) [mm]	2 x 3/16" [2 x 4.8 mm]		
G Net Aperture Dimensions Width (in) [mm]	32.5" [826 mm]	21.125" [537 mm]	46.625" [1184 mm]
Length (in) [mm]	74.5" [1892 mm]	165.375" [4200 mm]	94.75" [2407 mm]
H Net Aperture Area (ft^2) [m^2]	16.81 ft^2 [1.56 m^2]	24.26 ft^2 [2.25 m^2]	30.68 ft^2 [2.85 m^2]
I Aperture as % of Gross Area	87.4%	87.9%	97.5% ?
J Absorber Material(s) and Size Width (in) [mm]	Aluminum 22-gauge	0.020" Aluminum	0.032" Aluminum
Length (in) [mm]			
K Projections from Collector Panel and Location			
L Weight of Panel (lb) [kg]	81 lb [36.7 kg]		64 lb [29 kg]
M Comments/Remarks:	Ponderosa pine wood frame ($2\frac{5}{8}$"x $1\frac{1}{4}$") No insulation in collector.	Collector is designed as integrated roof/wall system. Integrated 1.625" standoff at back *Variable lengths from 144" to 216" in 24" increments available.	Back: 0.060" fiberglass reinforced sheet

FLAT PLATE COLLECTORS - AIR

MANUFACTURER AND LOCATION

Collector Characteristics	Sun Tech Solar Ind.Corp. Chester New York 10918	Energy Control Systems Raleigh North Carolina 27606	Gem Manufacturing Co. Bascom Ohio 44809
A Collector Panel: Model Name/No.	STS-100V (114)	Solar-Air	1149
B Listed Panel Dimensions: Width (in) [mm]	46.75" [1187 mm]	24.0" [610 mm]	25.125" [638 mm]
Length (in) [mm]	92.75" [2356 mm]	196.25" [4985 mm]	146.875" [3731 mm]
Depth (in) [mm]	2.0" [51 mm]	8.0" [203 mm]	3.3" [84 mm]
C Measured Panel Dimensions: Width (in) [mm]	47.25" [1200 mm]		
Length (in) [mm]	93.25" [2369 mm]		
Depth (in) [mm]	4.6875" [119 mm]		
D Gross Area of Panel (ft^2) [m^2]	30.6 ft^2 [2.84 m^2]	32.7 ft^2 [3.04 m^2]	25.62 ft^2 [2.38 m^2]
E Coordinating Dimensions: Width (in) [mm]			
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm]	Tempered glass		Tempered glass
Length (in) [mm]			
Thickness (in) [mm]	3/16" [4.8 mm]		3/16" [4.8 mm]
G Net Aperture Dimensions Width (in) [mm]	45.187" [1148 mm]		
Length (in) [mm]	91.25" [2318 mm]		
H Net Aperture Area (ft^2) [m^2]	28.63 ft^2 [2.66 m^2]		19.9 ft^2 [1.85 m^2]
I Aperture as % of Gross Area	93.6%		77.7%
J Absorber Material(s) and Size Width (in) [mm]	Aluminum 0.020" shaped		Aluminum 0.040"
Length (in) [mm]			
K Projections from Collector Panel and Location	Ports top and bottom end		
L Weight of Panel (lb) [kg]			60 lb [27.2 kg]
M Comments/Remarks:	Aluminum frame and 24-g. back	To coordinate with standard rafter spacing at 24" (610 mm) cs.	Used with 24" rafter spacing

FLAT PLATE COLLECTORS - AIR

MANUFACTURER AND LOCATION

Collector Characteristics	Solar Energy Products Co. Avon Lake (SEPCO) Ohio 44012	Solar Energy Products Co. Avon Lake Ohio 44012	Solar I (Division of Mentor Stellar Ind.) Ohio 44060
A Collector Panel: Model Name/No.	Rom-Aire EF-212 (87)	Rom-Aire EF-48	1078 (80)
B Listed Panel Dimensions: Width (in) [mm]	25.125" [638 mm]	48.0" [1219 mm]	48.0" [1219 mm]
Length (in) [mm]	146.875" [3731 mm]	96.0" [2438 mm]	96.0" [2438 mm]
Depth (in) [mm]	3.3" [84 mm]	3.3" [84 mm]	8.0" [203 mm]
C Measured Panel Dimensions: Width (in) [mm]	25.125" [638 mm]		47.5" [1206 mm]
Length (in) [mm]	146.875" [3731 mm]		98.75" [2508 mm]
Depth (in) [mm]	3.25" [83 mm]		8.125" [206 mm]
D Gross Area of Panel (ft^2) [m^2]	25.63ft^2 [2.38 m^2]	32.0 ft^2 [2.97 m^2]	32.57 ft^2 [3.03 m^2]
E Coordinating Dimensions: Width (in) [mm]	24.0" [610 mm]		48.0" [1219 mm]
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm]	LOF Herculon temp. glass		Kalwall 0.040" + 0.025"
Length (in) [mm]			
Thickness (in) [mm]	1/8" [3.2 mm]		
G Net Aperture Dimensions Width (in) [mm]	20.0" [508 mm]		46.0" [1168 mm]
Length (in) [mm]	139.25" [3537 mm]		93.5625" [2376 mm]
H Net Aperture Area (ft^2) [m^2]	19.34 ft^2 [1.80 m^2]	29.0 ft^2 [2.7 m^2]	29.89 ft^2 [2.78 m^2]
I Aperture as % of Gross Area	75.5%	90.6%	91.8%
J Absorber Material(s) and Size Width (in) [mm]	0.018" ribbed aluminum 22.175" [563 mm]	0.018" ribbed aluminum 46.125" [1172 mm]	Zinc Alum alloy 0.020" to 0.040"
Length (in) [mm]	143.125" [3635 mm]	94.125" [2391 mm]	
K Projections from Collector Panel and Location			
L Weight of Panel (lb) [kg]	60 lb [27.2 kg]	105 lb [47.6 kg]	125 lb [56.7 kg]
M Comments/Remarks:	2 sheets of glazing with central support form the cover plate. (2/24" x 72") Width of housing is 22.125" (562 mm) for fit between members at 24" cs.		

FLAT PLATE COLLECTORS - AIR

MANUFACTURER AND LOCATION

Collector Characteristics	Solar Heat Co. Greenville Pennsylvania 16125	Solar Technology Inc. Dover Pennsylvania 17315	Solar Stor, Inc. Parker South Dakota 57053
A Collector Panel: Model Name/No.	Model CFA16	450 Deluxe (143)	128 (Sunsaver) (93)
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	101.25" [2572 mm] 185.625" [4715 mm] 13.25" [337 mm]	24.0" [610 mm] 144.0" [3658 mm]	96.0" [2438 mm] 193.75" [4921 mm] 9.25" [235 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]		25.0" [635 mm] 143.5" [3645 mm]	97.875" [2486 mm] 194.0" [4928 mm] 11.75" [298 mm]
D Gross Area of Panel (ft^2) [m^2]	130.5 ft^2 [12.13 m^2]	24.91 ft^2 [2.31 m^2]	131.86 ft^2 [12.25 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	1. 3/16" Low-iron Sunadex 2. 3/16" ASG Lustreglass 2 x 3/16" [4.8 mm]	0.040" Sunlite fibergl. 1/8" tempered glass	0.020" Polycarbonate double cover
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]	89.875" [2283 mm]	20.875" [530 mm] 139.375" [3540 mm]	92.25" [2343 mm] 177.0" [4496 mm]
H Net Aperture Area (ft^2) [m^2]		20.20 ft^2 [1.88 m^2]	113.39 ft^2 [10.53 m^2]
I Aperture as % of Gross Area		81.1%	86.0%
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	0.016" Al. plate and 0.025" Steel mesh	0.030" Aluminum plate 0.030" Perf. alum. fin	0.034" aluminum fins
K Projections from Collector Panel and Location			
L Weight of Panel (lb) [kg]	1600 lb [725 kg]		900 lb [400 kg]
M Comments/Remarks:	Collector is assembled as a module of 4 connected panels.		*Manufactured by Sunsaver Corporation, North Liberty, Iowa Collector has 4 sections and serpentine air flow. Comes with hinged reflectors.

FLAT PLATE COLLECTORS - AIR

MANUFACTURER AND LOCATION

Collector Characteristics	Research Products Corp. Madison Wisconsin 53701	SolaRay, Inc. Whitewater Wisconsin 53701	Sun Unlimited Research Corp. Sheboygan Wisconsin 54013
A Collector Panel: Model Name/No.	Suncell 601 (79)	Model 02-2* (81)	SCD 1578 (135)
B Listed Panel Dimensions: Width (in) [mm]	34.625" [879 mm]	48.0" [1219 mm]	40.5" [1029 mm]
Length (in) [mm]	76.56" [1945 mm]	142.0" [3607 mm]	81.25" [2064 mm]
Depth (in) [mm]	6.375" [162 mm]	8.44" [214 mm]	11.5" [292 mm]
C Measured Panel Dimensions: Width (in) [mm]	34.75" [883 mm]	48.0" [1219 mm]	
Length (in) [mm]	76.75" [1950 mm]	143.0" [3632 mm]	
Depth (in) [mm]	6.875" [175 mm]	2.375" [60 mm]*	
D Gross Area of Panel (ft^2) [m^2]	18.52 ft^2 [1.72 m^2]	47.67 ft^2 [4.43 m^2]	22.85 ft^2 [2.12 m^2]
E Coordinating Dimensions: Width (in) [mm]			
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm]	Double low iron temp. gl.	1. 1/8" acrylic 2. 1/8" DS float glass	
Length (in) [mm]			
Thickness (in) [mm]	2 x 1/8" [2 x 3.2 mm]		
G Net Aperture Dimensions Width (in) [mm]	32.625" [829 mm]	45.75" [1162 mm]	
Length (in) [mm]	74.625" [1895 mm]	44.75" [1137 mm] x 3	
H Net Aperture Area (ft^2) [m^2]	16.91 ft^2 [1.57 m^2]	42.65 ft^2 [3.96 m^2]	
I Aperture as % of Gross Area	91.3%	89.5%	
J Absorber Material(s) and Size Width (in) [mm]	6 layers 0.006" slit and expanded alum. matrix	0.032" aluminum sheet	
Length (in) [mm]			
K Projections from Collector Panel and Location			
L Weight of Panel (lb) [kg]	137 lb [62.1 kg]	186 lb [84.4 kg]	
M Comments/Remarks:		*Collector has 3 glazing modules of 46.94" x 45.875" and is a field-assembled from case and glazing modules.	Model SCD 2728 SQ used in DoE Collector Test Program.

FLAT PLATE COLLECTORS - AIR

MANUFACTURER AND LOCATION

Added

Collector Characteristics	Sun Unlimited Research Corp. Sheboygan Wisconsin 53081	West Central Wisconsin Community Action Agency Glenwood City Wisconsin 54013	Solar Technology Corp. Denver Colorado 80211
A Collector Panel: Model Name/No.	SCD 2878 SQ (135)	Simple Solar Matrix (77)	SUNUP Collector
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	34.625" [879 mm] 77.0" [1956 mm] 10.375" [264 mm]	48.0" [1219 mm] 96.0" [2438 mm] 6.0" [152 mm]	36.0" [914 mm] 78.0" [1981 mm]
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]		48.25" [1226 mm] var. 96.25" [2445 mm] var. 6.75" [171 mm]	
D Gross Area of Panel (ft^2) [m^2]	18.51 ft^2 [1.72 m^2]	32.25 ft^2 [3.00 m^2]	19.5 ft^2 [1.81 m^2]
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Low-iron tempered glass 3/16" [4.8 mm]	5-oz Filon	Thermoglass-double gl. 2 x 3/16" [2 x 4.8 mm]
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]	33.1875" [843 mm] 75.1875" [1910 mm]	45.5" [1156 mm] 93.5" [2375 mm]	
H Net Aperture Area (ft^2) [m^2]	17.33 ft^2 [1.61 m^2]	29.54 ft^2 [2.74 m^2]	
I Aperture as % of Gross Area	93.6%	91.6%	
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	28 gauge enameled steel	Crimped 1" high alum.	0.032" Aluminum
K Projections from Collector Panel and Location			
L Weight of Panel (lb) [kg]	80 lb [36.3 kg]	75 lb [34 kg]	
M Comments/Remarks:	Mounting top and bottom rear edges of panel		Also: 48.0" x 96.0" model (32 ft^2 nominal) [1219 mm x 2438 mm].

FLAT PLATE COLLECTORS - AIR

MANUFACTURER AND LOCATION

Collector Characteristics			
A Collector Panel: Model Name/No.			
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]			
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]			
D Gross Area of Panel (ft^2) [m^2]			
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]			
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]			
H Net Aperture Area (ft^2) [m^2]			
I Aperture as % of Gross Area			
J Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]			
K Projections from Collector Panel and Location			
L Weight of Panel (lb) [kg]			
M Comments/Remarks:			

APPENDIX 3

FLAT PLATE COLLECTORS -

SPECIAL TYPES

FLAT PLATE COLLECTORS - FOCUSING REFLECTOR TYPE

MANUFACTURER AND LOCATION

Collector Characteristics	Solergy, Inc. San Francisco California 94107	Falbel Energy Systems Corp. Greenwich Connecticut 06830	Solarcell Corporation Ft. Lauderdale Florida 33334
A Collector Panel: Model Name/No.	Solergy Model 1-A (72)	Model 31 AC (103)	Model S-10
B Listed Panel Dimensions: Width (in) [mm]	48.0" [1219 mm]	48.0" [1219 mm]	47.50" [1206 mm] Drwg
Length (in) [mm]	96.0" [2438 mm]	96.0" [2438 mm]	70.25" [1784 mm] "
Depth (in) [mm]	4.0" [102 mm]	6.0" [152 mm]	4.75" [121 mm] "
C Measured Panel Dimensions: Width (in) [mm]	48.1875" [1224 mm]	48.25" [1226 mm]	47.44" [1205 mm] FSEC
Length (in) [mm]	96.1875" [2443 mm]	96.25" [2445 mm]	70.16" [1782 mm] "
Depth (in) [mm]	4.375" [111 mm]	7.125" [181 mm]	4.75" [121 mm] "
D Gross Area of Panel (ft^2) [m^2]	32.19 ft^2 [2.99 m^2]	32.25 ft^2 [3.00 m^2]	23.11 ft^2 [2.15 m^2]
E Coordinating Dimensions: Width (in) [mm]			
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions:	Outer: Acrylic 0.125" Inner: Teflon 0.001"	Clear Acrylic 0.080"	Acrylic 0.125"
Width (in) [mm]			
Length (in) [mm]			
Thickness (in) [mm]	0.125" [3.2 mm]	0.080" [2.0 mm]	0.125" [3.2 mm]
G Net Aperture Dimensions Width (in) [mm]	46.25" [1175 mm]	46.125" [1172 mm]	[1046 mm] FSEC
Length (in) [mm]	94.25" [2394 mm]	94.25" [2394 mm]	[1630 mm] "
H Net Aperture Area (ft^2) [m^2]	30.27 ft^2 [2.81 m^2]	30.19 ft^2 [2.80 m^2]	18.35 ft^2 [1.70 m^2]
I Aperture as % of Gross Area	(94%)	(93.6%)	(79.4%)
J Reflector(s) - Number and Size Width (in) [mm]	12 mylar curved reflec- reflectors, 0.875" copper absorbing tubes. 1.125" manifold.	4 curved alum. reflec- tors 11.625" [295 mm] wide with 3/8" copper tube with snap-in al. fins	6 reflectors plated on- to ABS plastic, with 0.75" copper tube.
Length (in) [mm]			
K Projections from Collector Panel and Location	1.125"O.D. manifold from sides, 2.375" diag. opp.	Inlet/outlet at narrow end, 1.5"	Inlet/outlet at narrow end, diag. opp.
L Weight of Panel Empty (lb) [kg]	75 lb [34 kg]	100 lb [45 kg]	68.5 lb [31.1 kg]
Full (lb) [kg]			
M Comments/Remarks:	0.040" Alum. frame and backing. Designed for horizontal mounting	0.032" Alum housing Combination of parallel and serpentine flow	ABS plastic enclosure with alum. trim. Serpentine flow pattern

FLAT PLATE COLLECTORS - FOCUSING REFLECTOR TYPE

MANUFACTURER AND LOCATION

Collector Characteristics	Solar Industries of Florida Jacksonville Florida 32208	General Solar Systems Div General Extrusions, Inc. Youngstown Ohio 44507	
A Collector Panel: Model Name/No.	Suntrak A-1000 (38)	LTC-367 (5)	
B Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]		53.75" [1365 mm] Drwg. 118.0" [2997 mm] " 6.75" [171 mm]	
C Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	37.50" [952 mm] 97.75" [2483 mm] 4.5" [114 mm]		
D Gross Area of Panel (ft^2) [m^2]	25.46 ft^2 [2.36 m^2]	44.04 ft^2 [4.09 m^2]	
E Coordinating Dimensions: Width (in) [mm] Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Tempered glass 1/8" [3.2 mm]	Swedcast 300 Acrylic 0.118" [2.5 mm]	
G Net Aperture Dimensions Width (in) [mm] Length (in) [mm]	34.25" [870 mm] 2 panels 93.25" [2369 mm] 4 panels		
H Net Aperture Area (ft^2) [m^2]	22.18 ft^2 [2.06 m^2]	32.7 ft^2 [3.04 m^2]	
I Aperture as % of Gross Area	(87.1%)	74.3%	
J Reflector(s) - Number and Size Width (in) [mm] Length (in) [mm]		5 parabolic reflectors w. alum. fin tube absorber	
K Projections from Collector Panel and Location	0.625" copper inlet/outlet at one narrow side	Inlet/outlet long side	
L Weight of Panel Empty (lb) [kg] Full (lb) [kg]		245 lb [111.1 kg]	
M Comments/Remarks:	Alum. frame. Serpentine copper flow tubes. Mounting horizontal.	All aluminum module. Special mounting rail and clips.	

FLAT PLATE COLLECTORS - SPRAYED WATER

MANUFACTURER AND LOCATION

Collector Characteristics	Solar Energy Research Corp. Longmont Colorado 80501		
A Collector Panel: Model Name/No.	Thermo-Spray WT 2-8 (57)		
B Listed Panel Dimensions: Width (in) [mm]	23.75" [603 mm]		
Length (in) [mm]	86.0" [2184 mm]		
Depth (in) [mm]			
C Measured Panel Dimensions: Width (in) [mm]	23.625" [600 mm]		
Length (in) [mm]	86.125" [2188 mm]		
Depth (in) [mm]	7.5" [190 mm]		
D Gross Area of Panel (ft^2) [m^2]	14.13 ft^2 [1.31 m^2]		
E Coordinating Dimensions: Width (in) [mm]	24.0" [610 mm]		
Length (in) [mm]			
F Cover Plate Material(s) and Dimensions: Width (in) [mm]	Lexan FRP 0.040" curved		
Length (in) [mm]			
Thickness (in) [mm]	0.040" [1.0 mm]		
G Net Aperture Dimensions Width (in) [mm]	21.375" [543 mm]		
Length (in) [mm]	74.75" [1899 mm]		
H Net Aperture Area (ft^2) [m^2]	11.10 ft^2 [1.03 m^2]		
I Aperture as % of Gross Area	78.6%		
J Absorber Material(s) and Size Width (in) [mm]	0.010" copper shaped pl.		
Length (in) [mm]			
K Projections from Collector Panel and Location	Inlet/outlet		
L Weight of Panel Empty (lb) [kg]	95 lb [43 kg]		
Full (lb) [kg]			
M Comments/Remarks:	20-gauge galv. steel housing. Fixed angle or variable tilt mounting. Can be used for cooling. Dimensions are not consistent in trade info.		

FLAT PLATE COLLECTORS - LIQUID EVACUATED PANEL

MANUFACTURER AND LOCATION

	Collector Characteristics	Solar Systems, Inc. Tyler Texas 75702		
A	Collector Panel: Model Name/No.	Solarvak 78-A (4)		
B	Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	49.0" [1245 mm] 97.0" [2464 mm] 5.0" [127 mm]		
C	Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	48.625" [1235 mm] 96.625" [2454 mm] var. 6.25" [159 mm]		
D	Gross Area of Panel (ft^2) [m^2]	32.63 ft^2 [3.03 m^2]		
E	Coordinating Dimensions: Width (in) [mm] Length (in) [mm]			
F	Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Shaped acrylic 0.250" 0.250" [6.4 mm]		
G	Net Aperture Dimensions Width (in) [mm] Length (in) [mm]	45.0" [1143 mm] varies 93.0" [2362 mm] varies		
H	Net Aperture Area (ft^2) [m^2]	29.0 ft^2 [2.7 m^2]		
I	Aperture as % of Gross Area	89% approx.		
J	Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	0.0216" copper plate with serpentine 3/8" tube.		
K	Projections from Collector Panel and Location	Inlet/outlet below collector, up to 4.5" proj.		
L	Weight of Panel Empty (lb) [kg] Full (lb) [kg]	160 lb [72.6 kg]		
M	Comments/Remarks:	Module has 1/4" acrylic shaped housings with absorber plate suspended in between. Size tolerances ±0.125".		

FLAT PLATE COLLECTORS - EVACUATED TUBE

MANUFACTURER AND LOCATION

Collector Characteristics				
		General Electric Company Advanced Energy Programs Philadelphia Pennsylvania 19101		
A	Collector Panel: Model Name/No.	*TC 100 Vacuum Tube Collector		
B	Listed Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]	47.75" [1213 mm] 52.5" [1334 mm] 3.25" [83 mm]		
C	Measured Panel Dimensions: Width (in) [mm] Length (in) [mm] Depth (in) [mm]			
D	Gross Area of Panel (ft^2) [m^2]			
E	Coordinating Dimensions: Width (in) [mm] Length (in) [mm]	48.0" [1219 mm]		
F	Cover Plate Material(s) and Dimensions: Width (in) [mm] Length (in) [mm] Thickness (in) [mm]	Optional: Lexan FRP or Acrylic protective cover Lexan 0.060" [1.5 mm]		
G	Net Aperture Dimensions Width (in) [mm] Length (in) [mm]	Not applicable		
H	Net Aperture Area (ft^2) [m^2]			
I	Aperture as % of Gross Area			
J	Absorber Material(s) and Size Width (in) [mm] Length (in) [mm]	10 glass vacuum tubes w. alum. reflective V-trough		
K	Projections from Collector Panel and Location	Inlet/outlet connections at bottom end		
L	Weight of Panel Empty (lb) [kg] Full (lb) [kg]	60 lb [27.2 kg] 62 lb [28.1 kg]		
M	Comments/Remarks:	Solar module enclosure aluminum, with mounting holes for corner brackets. *Trade Name: Solartron. Outer glass tube, inner serpentine copper tube.		

APPENDIX 4

LISTING OF MEASURED SOLAR COLLECTOR SIZES (WIDTH, LENGTH, AND AREA)

LISTING OF MEASURED COLLECTOR SIZES SHOWING WIDTH FIRST [Dimensions in inches]

Liquid Flat Plate Collectors

20.00" - 27.99"	28.00" - 35.99"	36.00" - 43.99"	44.00" - 52.00"
21.5" x 73.875"	28.188" x 113.0"	36.0" x 60.0"	44.7" x 72.85"
22.64" x 96.25"	29.938" x 90.16"	36.0" x 78.0"	44.75" x 81.0"
23.0" x 95.75"	32.063" x 96.25"	36.0" x 78.125"	45.25" x 96.975"
23.75" x 61.50"	32.375" x 97.438"	36.0" x 78.125"	46.375" x 76.5"
23.83" x 96.125"	34.125" x 74.625"	36.0" x 84.063"	47.0" x 120.0"
24.0" x 96.125"	34.25" x 99.625"	36.0" x 97.875"	47.438" x 150.56"
24.063" x 96.125"	34.5" x 76.38"	36.125" x 94.375"	47.5" x 120.5"
24.063" x 100.5"	34.625" x 92.625"	36.125" x 154.4"	47.563" x 95.563"
24.125" x 96.25"	34.75" x 74.3"	36.25" x 78.375"	47.563" x 143.563"
24.25" x 96.0"	34.75" x 92.75"	36.25" x 84.375"	47.875" x 120.0"
24.375" x 97.375"	34.875" x 76.875"	36.438" x 90.563"	48.1" x 96.125"
24.6" x 120.375"	35.0" x 96.0"	36.438" x 102.0"	48.125" x 96.125"
	35.25" x 77.375"	36.75" x 108.813"	48.125" x 120.125"
	35.25" x 97.375"	36.813" x 108.75"	48.125" x 121.125"
	35.375" x 77.375"	36.875" x 96.875"	48.188" x 96.188"
	35.375" x 77.5"	37.125" x 99.375"	48.375" x 190.0"
	35.5" x 77.375"	37.375" x 99.25"	48.425" x 147.125"
	35.5" x 77.5"	37.75" x 97.75"	48.45" x 120.313"
	35.5" x 77.625"	38.063" x 120.875"	48.5" x 72.375"
	35.5" x 84.0"	38.125" x 78.063"	48.5" x 93.313"
	35.5" x 160.0"	38.188" x 105.875"	48.5" x 94.625"
	35.625" x 77.625"	39.0" x 81.0"	48.5" x 95.25"
	35.75" x 77.75"	39.0" x 100.75"	48.5" x 96.5"
	35.875" x 71.813"	40.0" x 99.5"	48.5" x 98.5"
	35.875" x 75.875"	40.25" x 88.125"	48.5" x 98.625"
	35.875" x 77.875"	40.25" x 118.5"	48.625" x 96.625"
	35.875" x 98.0"	40.625" x 110.0"	48.875" x 97.875"
		40.75" x 96.3"	48.875" x 120.9"
		41.875" x 97.125"	48.875" x 120.938"
		43.125" x 107.0"	49.5" x 145.5"
		43.375" x 107.125"	49.75" x 112.75"
			50.063" x 98.125"
			51.0" x 102.85"

Air Flat Plate Collectors*

24.0" x 168.25"	32.0" x 84.0"	38.125" x 86.125"	47.25" x 93.25"
25.0" x 143.5"	34.75" x 76.75"		47.375" x 95.625"
25.125" x 146.875"	34.875" x 76.875"		47.5" x 98.75"
	35.625" x 77.75"		48.0" x 143.0"
			48.25" x 96.25"
			49.375" x 97.375"

* 2 additional site-built collectors
97.875" x 194.0" and 150.0" x 103.25"

LISTING OF MEASURED COLLECTOR SIZES SHOWING WIDTH FIRST [Dimensions in mm]

Liquid Flat Plate Collectors

500 mm - 700 mm	700 mm - 900 mm	900 mm - 1100 mm	1100 mm - 1300 mm
546 x 1876	716 x 3870	902 x 1965	1102 x 2720
575 x 2445	760 x 2290	902 x 1968	1135 x 1850
584 x 2432	814 x 2445	902 x 1972	1137 x 2057
603 x 1562	822 x 2373	902 x 2134	1150 x 2461
605 x 2442	867 x 1895	902 x 4064	1178 x 1943
611 x 2442	870 x 2454	905 x 1972	1194 x 3048
611 x 2442	876 x 1940	908 x 1975	1207 x 3060
611 x 2553	879 x 2353	911 x 1824	1208 x 2427
613 x 2445	883 x 1887	911 x 1927	1208 x 3646
616 x 2438	883 x 2356	911 x 1978	1216 x 3048
625 x 3058	886 x 1953	911 x 2489	1222 x 2442
	895 x 1965	914 x 1524	1222 x 2445
	895 x 2473	914 x 1981	1224 x 3077
	899 x 1965	914 x 1984	1229 x 4826
	899 x 1968	914 x 2135	1230 x 3737
		914 x 2486	1231 x 3056
		915 x 1984	1232 x 1838
		918 x 2397	1232 x 2320
		918 x 3923	1232 x 2403
		921 x 1991	1232 x 2419
		921 x 2143	1232 x 2451
		925 x 2300	1232 x 2502
		925 x 2591	1232 x 2505
		933 x 2764	1235 x 2442
		935 x 2762	1241 x 3071
		937 x 2461	1241 x 3072
		943 x 2524	1257 x 3696
		949 x 2521	1264 x 2864
		959 x 2483	1267 x 2486
		967 x 3070	1272 x 2492
		968 x 1983	1296 x 2612
		970 x 2690	
		990 x 2057	
		991 x 2559	
		1016 x 2527	
		1022 x 2238	
		1022 x 3010	
		1032 x 2794	
		1035 x 2446	
		1064 x 2467	
		1095 x 2718	

Air Flat Plate Collectors*

610 x 4274	813 x 2135	905 x 1973	1200 x 2369
635 x 3645	883 x 1950	968 x 2188	1206 x 2508
638 x 3731	886 x 1953		1219 x 2438
			1219 x 3632
			1226 x 2445
			1254 x 2473

* 2 additional site-built collectors
1829 x 2438 and 3816 x 2629

LISTING OF MEASURED COLLECTOR SIZES SHOWING LENGTH FIRST [Dimensions in mm]

Liquid Flat Plate Collectors

Under 2100 mm	2100 - 2400 mm	2400 - 2700 mm	2700 - 3000 mm	Over 3000 mm
1524 x 914	2134 x 902	2403 x 1232	2718 x 1095	3010 x 1022
1562 x 603	2135 x 914	2419 x 1232	2720 x 1102	3048 x 1194
1824 x 911	2143 x 1137	2427 x 1208	2762 x 935	3048 x 1216
1838 x 1232	2238 x 1022	2432 x 584	2764 x 933	3051 x 1222
1850 x 1135	2290 x 760	2438 x 822	2794 x 1032	3056 x 1231
1876 x 546	2300 x 925	2442 x 605	2864 x 1264	3058 x 625
1887 x 883	2320 x 1232	2442 x 610	2870 x 716	3060 x 1207
1895 x 867	2353 x 879	2442 x 611		3070 x 967
1927 x 911	2356 x 883	2442 x 1222		3071 x 1241
1940 x 876	2397 x 918	2442 x 1222		3072 x 1241
1943 x 1178		2445 x 575		3077 x 1224
1953 x 886		2445 x 613		3646 x 1208
1965 x 895		2445 x 814		3696 x 1257
1965 x 899		2446 x 1035		3737 x 1230
1965 x 902		2451 x 1232		3923 x 918
1968 x 899		2454 x 870		4064 x 902
1968 x 902		2454 x 1235		4826 x 1229
1972 x 902		2461 x 937		
1972 x 905		2461 x 1150		
1975 x 908		2467 x 1064		
1978 x 911		2473 x 619		
1981 x 914		2473 x 895		
1983 x 968		2483 x 959		
1984 x 914		2486 x 914		
1984 x 915		2486 x 1267		
1991 x 921		2489 x 911		
2057 x 990		2492 x 1272		
2057 x 1137		2502 x 1232		
		2505 x 1232		
		2521 x 949		
		2524 x 943		
		2527 x 1016		
		2553 x 611		
		2559 x 991		
		2591 x 925		
		2612 x 1296		
		2690 x 970		

Air Flat Plate Collectors

1950 x 883	2135 x 813	2438 x 1219	3632 x 1219
1953 x 886	2188 x 968	2445 x 1226	3645 x 635
1973 x 905	2369 x 1200	2473 x 1254	3731 x 638
		2508 x 1206	4274 x 610

GROSS AREA [A_g] OF SOLAR COLLECTORS BASED ON MEASURED DATA (in ft^2)

Liquid Flat Plate Collectors

Under 20 ft^2	20 - 25 ft^2	25 - 30 ft^2	30 - 40 ft^2	40 - 50 ft^2	Over 50 ft^2
10.14	20.57	25.17	30.44	40.15	50.02
11.03	20.67	25.62	31.03	40.48	63.83
15.00	20.71	25.63	31.43	40.49	
15.13	21.02	25.76	31.56	41.02	
15.29	21.24	25.81	31.87	41.05	
15.91	21.43	27.25	31.95	47.42	
16.02	21.91	27.29	32.04	49.48	
16.06	21.94	27.64	32.07	49.60	
16.13	22.12	27.77	32.11		
16.17	22.27	27.80	32.13		
16.48	22.38	28.09	32.27		
16.79	22.60	28.24	32.62		
17.68	22.92		33.12		
17.89	22.98		33.18		
17.93	23.33		33.22		
18.30	23.68		33.90		
18.62	23.84		34.11		
18.73	24.37		35.50		
18.90	24.41		36.44		
18.94	24.47		38.73		
19.01	24.63		38.95		
19.01	24.64		39.16		
19.04	24.81		39.44		
19.11			39.75		
19.14			39.90		
19.20					
19.30					
19.40					
19.50					
19.53					
19.54					
19.73					

Air Flat Plate Collectors

18.52	22.80	25.30	30.60	47.67	107.73
18.62	24.91	25.63	31.46	48.00	131.86
18.68		28.04	32.25		
19.24			32.57		
			33.39		

APPENDIX 5

DEVIATION OF MEASURED COLLECTOR SIZES FROM SPECIFIED SIZES

DEVIATION OF MEASURED DIMENSION FROM SPECIFIED DIMENSION (in inches)

Length of Collector

Deviation (inches)	Liquid F.P.	Air F.P.	Special	Total
+ 3.375"	1	-	-	1
+ 2.75"	-	1	-	1
+ 1.875"	1	-	-	1
+ 1.5"	2	-	-	2
+ 1.125"	1	-	-	1
+ 1.0"	-	1	-	1
+ 0.875"	2	-	-	2
+ 0.75" (0.69")	2	-	-	2
+ 0.625"	2	-	-	2
+ 0.5"	4	1	-	5
+ 0.375"(0.4")	7	-	-	7
+ 0.3125" (0.3")	2	-	-	2
+ 0.25"	8	1	1	10
+ 0.1875" (0.16")	3	1	1	5
+ 0.125" (0.1", 0.09")	23	5	1	29
+ 0.0625"	2	1	-	3
0	23	2	-	25
- 0.0625"	1	1	-	2
- 0.125" (0.12", 0.09")	6	-	1	7
- 0.1875"	4	-	-	4
- 0.25"	1	-	-	1
- 0.375"	-	1	1	2
- 0.5"	1	1	-	2
- 0.775"	1	-	-	1
- 1.0"	1	-	-	1
- 1.375"	1	-	-	1
- 2.6875"	1	-	-	1
Total	100	16	5	121
Total number larger	60 (60%)	11 (69%)	3 (60%)	74 (61.2%)
Total number exact	23 (23%)	2 (12%)	-	25 (20.6%)
Total number smaller	17 (17%)	3 (19%)	2 (40%)	22 (18.2%)
Range -0.125" to +0.25"	66 (66%)	11 (69%)	4 (80%)	81 (66.9%)

DEVIATION OF MEASURED COLLECTOR AREA FROM LISTED AREA (in square feet)

Deviation (ft^2)	Liquid F.P.	Air F.P.	Special	Total
Exceeding 2 ft^2	-	1	-	1
+ 1.51 ft^2 - 2.00 ft^2	3	-	-	3
+ 1.01 ft^2 - 1.50 ft^2	1	-	-	1
+ 0.76 ft^2 - 1.00 ft^2	1	1	-	2
+ 0.51 ft^2 - 0.75 ft^2	5	1	-	6
+ 0.41 ft^2 - 0.50 ft^2	7	1	-	8
+ 0.31 ft^2 - 0.40 ft^2	4	1	-	5
+ 0.21 ft^2 - 0.30 ft^2	6	1	1	8
+ 0.11 ft^2 - 0.20 ft^2	10	3	1	14
0 to + 0.10 ft^2	21	3	-	24
0	11	2	-	13
0 to - 0.10 ft^2	14	1	2	17
- 0.11 ft^2 - 0.20 ft^2	8	-	-	8
- 0.21 ft^2 - 0.30 ft^2	6	-	-	6
- 0.31 ft^2 - 0.40 ft^2	-	1	1	2
- 0.41 ft^2 - 0.50 ft^2	1	-	-	1
- 0.51 ft^2 - 0.75 ft^2	1	-	-	1
- 0.76 ft^2 - 1.00 ft^2	1	-	-	1
Total	100	16	5	121
Total number larger	58 (58%)	12 (75%)	2 (40%)	72 (59.5%)
Total number exact	11 (11%)	2 (12.5%)	-	13 (10.7%)
Total number smaller	31 (31%)	2 (12.5%)	3 (60%)	36 (29.8%)
Range -0.1 ft^2 to +0.1 ft^2	46 (46%)	6 (37.5%)	2 (40%)	54 (44.6%)
Range -0.2 ft^2 to +0.2 ft^2	64 (64%)	9 (56%)	3 (60%)	76 (62.8%)

DEVIATION OF MEASURED DIMENSION FROM SPECIFIED DIMENSION (in inches)

Width of Collector

Deviation (inches)	Liquid F.P.	Air F.P.	Special	Total
+ 1.875"	-	1	-	1
+ 1.75"	1	-	-	1
+ 1.375"	1	-	-	1
+ 1.25"	2	-	-	2
+ 1.0"	-	1	-	1
+ 0.875"	1	-	-	-
+ 0.75" (0.69")	2	-	-	2
+ 0.625"(0.6")	3	-	-	3
+ 0.5"	6	1	-	7
+ 0.425"	1	-	-	1
+ 0.375"	5	-	-	5
+ 0.3125"	1	-	-	1
+ 0.25"	6	1	1	8
+ 0.1875" (0.2")	2	-	1	3
+ 0.125" (0.1")	12	4	-	16
+ 0.0625" (0.075")	7	-	-	7
0	24	5	-	29
- 0.0625"(0.06")	5	-	1	6
- 0.125"	10	1	1	12
- 0.1875"(0.17")	3	-	-	3
- 0.25"	2	-	-	2
- 0.3125"	2	-	-	2
- 0.375"	1	1	1	3
- 0.5"	1	1	-	2
- 0.625"	1	-	-	1
- 1.0"	1	-	-	1
Total	100	16	5	121
Total number larger	50 (50%)	8 (50%)	2 (40%)	60 (49.6%)
Total number exact	24 (24%)	5 (31%)	-	29 (24.0%)
Total number smaller	26 (26%)	3 (19%)	3 (60%)	32 (26.4%
Range -0.125" to 0.25"	66 (66%)	11 (69%)	4 (80%)	81 (66.9%)

APPENDIX 6

TABULATION OF INLET/OUTLET LOCATIONS IN LIQUID FLAT PLATE COLLECTORS BASED ON 4 CATEGORIES AND 12 TYPES

LOCATION OF INLET(S) AND OUTLETS OF LIQUID FLAT PLATE COLLECTORS FOR WHICH MEASURED OR SPECIFIED DATA WERE AVAILABLE

Category 1, Type A: Diagonally Opposite in End Walls (Bottom Left, Top Right)

Manufacturer and Location		Collector Model	Centerline Distance from Corner Bottom Left Inches	mm	Top Right Inches	mm
Energy Systems, Inc.	CA	1111D	2.25"	57	2.625"	67
Int. Solar Leasing Co.	CA	100C	2.6875"	68	3.0"	76
Sun Power Systems Ltd.	CA	C38B (Alt)	3.625"	92	3.625"	92
Hyperion, Inc.	CO	SPW-1001	1.75"	44	1.875"	48
Sunworks	CT	Solector (Alt)	2.5"	64	2.5"	64
Semco Corporation	FL	Tropic Sun TF-40	1.875"	48	1.75"	44
Solar Research Div.	MI	5849 Hydronic	1.625"	41	1.625"	41
Solergy Co.	MN	SG-100	2.75"	70	3.0"	76
E.S.P., Inc.	NJ	ESP-SCW	2.625"	67	2.5"	64
Revere	NY	Sun-Aid	3.0"	76	3.0"	76
Sunray Solar Heat, Inc.	NY	SR-4-1	1.625"	41	1.875"	48
LOF Solar En. Systems	OH	SunPanel 121	1.625"	41	1.625"	41
PPG Industries, Inc.	PA	Model C-512	2.094"	53	2.5625"	65
Heliosystems Corp.	TX	MT 200 C	3.75"	95	3.5"	89

Total number of models for which dimensional information is available: 14

Range of centerline distances from corner: Bottom Left: 1.625" - 3.75"
Top Right: 1.625" - 3.625"

Category 1, Type B: Diagonally Opposite in End Walls (Bottom Right, Top Left)

Manufacturer and Location		Collector Model	Centerline Distance from Corner Bottom Right Inches	mm	Top Left Inches	mm
Aircraftsman	AL	A2	2.875"	73	3.0"	76
Solar En. Products	CA	CU 30-WW	2.10"	53	2.40"	61
Solar II Enterprises	CA	CG-231	3.50"	89	3.50"	89
Novan Energy	CO	EC-200L	3.0"	76	2.5"	64
Aztec Solar Co.	FL	Sundevil III	3.0"	76	2.875"	73
Gulf Thermal Corp.	FL	CUS 30 WW	2.375"	60	2.375"	60
Hawaiian Sunpak Corp	HI	HS 101	5.0"	127	5.0"	127
Chamberlain Manuf.	IL	711101 & 711102	2.875"	73	2.75"	70
Columbia Chase	MA	Redi-Mount 3494	5.75"	146	5.75	146
Dumont Industries	ME	SA-4	3.0"	76	3.0"	76
Grumman En. Systems	NY	60F	5.5"	140	5.5"	140
Grumman En. Systems	NY	100F & 200F	3.5"	89	3.5"	89
Grumman En. Systems	NY	300 Series	2.625"	67	2.625"	67
Solartec, Inc.	OH	Model 101	1.75"	44	1.75"	44
American Solar King	TX	DG-15	3.75"	95	3.75"	95
Heliosystems Corp.	TX	MT 200 C (Alt)	3.5"	89	3.5"	89
Solar Alternative, Inc.	VT	Solite Model III	2.25"	57	2.125"	54
Solar One, Ltd.	VA	Sol 16	2.25"	57	2.25"	57

Total number of models for which dimensional information is available: 20

Range of centerline distances from corner: Bottom Right: 1.75" - 5.75"
Top Left: 1.75" - 5.75"

Category 1, Type C: Directly Opposite in End Walls (Bottom Center, Top Center)

Manufacturer and Location		Collector Model	Centerline Distance from Corner Inches	mm
Southwest Solar Corp.	CA	Solar Disc 1000	11.5"	292
Sunsav, Inc.	MA	SS-6	20.75"	527
Vulcan Solar Indust.	RI	CC-1F/G Sunline	21.59"	548

Total number of models for which dimensional information is available: 3

Category 1, Type D: Directly Opposite in End Walls (Bottom Left, Top Left)

Manufacturer and Location		Collector Model	Centerline Distance from Corner Inches	mm
Ametek, Inc., PSG	PA	Sun Jammer D-222	4.53"	115

Category 2, Type E: Diagonally Opposite in Side Walls (Lower Left, Upper Right)

Manufacturer and Location		Collector Model	Centerline Distance from Corner Lower Left Inches	mm	Upper Right Inches	mm
Solergy, Inc.	CA	1-A	2.625"	67	2.75"	70
Acorn Sunwave En. Sys.	MA	410-Sunwave	4.25"	108	2.75"	70
Cole Solar Systems	TX	410 A & AT	1.50"	38	1.50"	38

Total number of models for which dimensional information is available: 3

Category 2, Type F: Diagonally Opposite in Side Walls (Lower Right, Upper Left)

Manufacturer and Location		Collector Model	Centerline Distance from Corner Lower Right Inches	mm	Upper Left Inches	mm
Ying Manuf. Corp.	CA	SP 4120	1.75"	44	1.75"	44
American Solar Heat	CT	Amsolheat SP	1.125"	29	1.125"	29
Unit Electric Control	FL	Sol-Ray 1-6-50M	1.5"	38	1.5"	38
Ecotope Group	WA	Ecotope Rain	3.125"	79	3.875"	98

Total number of models for which dimensional information is available: 4

Category 2, Type G: Directly Opposite in Side Walls (Upper Left and Right, or reversed)

Manufacturer and Location		Collector Model	Centerline Distances from Corner Upper Left Inches	mm	Upper Right Inches	mm
Bio Energgy Systems	NY	Solaroll TG-32	4.50"	114	2.75"	70

Category 2, Type H: Inlets and Outlets in Side Walls (Lower Left, Upper Left, Lower Right, Upper Right)

Note: When connected in an array, the end units can be plugged at Upper Left and Lower Right, or Upper Right and Lower Left, depending on the direction of flow)

Manufacturer and Location		Collector Model	Centerline Distances from Corner							
			Upper Left		Upper Right		Lower Left		Lower Right	
			Inches	mm	Inches	mm	Inches	mm	Inches	mm
Sunshine Unlimited	AZ	A-Style Vert.	2.5"	64	2.5"	64	2.5"	64	2.5"	64
American Solar Ind.	CA	Raymaster I	2.5"	64	2.5"	64	2.5"	64	2.5"	64
Insolarator	CA	SAI20-125 SS	1.75"	44	1.75"	44	1.75"	44	1.75"	44
Pacific Solar Syst.	CA	I.S.L.C. C-9121	1.5"	38	1.5"	38	1.5"	38	1.5"	38
Sun Power Systems	CA	Sun-Panel C38B	2.0"	51	2.0"	51	2.0"	51	2.0"	51
Western Energy Inc.	CA	Solera 3492	1.75"	44	1.75"	44	1.75"	44	1.75"	44
Federal Energy Co.	CO	F-200	3.75"	95	3.75"	95	3.75"	95	3.75"	95
Sunworks	CT	Solector (Alt)	1.63"	41	1.63"	41	2.25"	57	2.25"	57
C.B.M. Manufact.	FL	20-34-92	1.5"	38	1.63"	41	1.5"	38	1.63"	41
Solar Prod. Sun-Tank	FL	Model 300A	3.75"	95	3.75"	95	3.75"	95	3.75"	95
Wallace Co.	GA	1208C	2.25"	57	2.25"	57	2.0"	51	2.0"	51
Precision Indust.	HI	AP-18	2.0"	51	2.0"	51	2.0"	51	2.0"	51
Acorn Sunwave En.	MA	410-Sunwave	2.75"	70	2.75"	70	4.25"	108	4.25"	108
Daystar Corp.	MA	Daystar 21-B	2.25"	57	2.19"	56	2.25"	57	2.13"	54
Solar USA, Inc.	NJ	Model 28 S	5.38"	137	5.5"	140	?	?	?	?
Sun Life Solar Pr.	OR	SP-100	1.63"	41	1.63"	41	1.63"	41	1.63"	41
PPG Industries	PA	C-224 & C-524	2.38"	60	2.38"	60	2.38"	60	2.38"	60
Sunearth Solar Pr.	PA	3597-PFA	1.75"	44	1.75"	44	1.75"	44	1.75"	44
Solar Enterprises	TX	Slimliner	1.88"	48	1.88"	48	1.88"	48	1.88"	48
Intertechnology S.C.	VA	Mark V	2.25"	57	2.25"	57	1.75"	44	1.75"	44

Total number of models for which dimensional information is available: 21

Range of centerline distances from corner:
Upper Left: 1.5" - 5.38"
Upper Right: 1.5" - 5.5"
Lower Left: 1.5" - 4.25"
Lower Right: 1.5" - 4.25"

Average distance of centerline from corner:
Upper Left: 2.375" 60 mm
Upper Right: 2.375" 60 mm
Lower Left: 2.25" 57 mm
Lower Right: 2.25" 57 mm

Category 3, Type J: Inlet and Outlet in Same Side Wall (Reversible)

Manufacturer and Location		Collector Model	Centerline Distance from Corner			
			Upper Right		Lower Right	
			Inches	mm	Inches	mm
Halstead & Mitchell	AL	Sunceiver II	2.125"	54	2.875"	73
Solarom Industries	NY	SCO-200	2.125"	54	2.125"	54

Other Manufacturers (No Dimensional Data):

Solar Unlimited, Inc.	AL	Model H1 Suncatcher	Serpentine flow
The Stolle Corporation	OH	Model Type AS	Serpentine flow

Category 3, Type K: Inlet and Outlet in Same End Wall (Reversible)

Manufacturer and Location		Collector Model	Centerline Distances from Corner Lower Left Inches	Lower Left mm	Lower Right Inches	Lower Right mm
Simons Solar Env. Sys.	PA	WCA	3.625"	92	2.625"	67
Maui Econ. Opp., Inc	HI	Meo-Maui Type 4x8	5.5 "	140	5.50"	140

Note: Many collectors listed under Type L, for horizontal configurations, may also be used in a vertical position, since they have a serpentine flow pattern.

Category 3, Type L: Inlet and Outlet in Short Side (Reversible)
Placement of collectors with long side horizontal

Manufacturer and Location		Collector Model		Centerline Distances from Corner Inlet (Lower) Inches	Inlet (Lower) mm	Outlet (Upper) Inches	Outlet (Upper) mm
D.W. Browning Contr.	FL	Model B	(S)	6.50"	165	6.50"	165
CSI Solar Systems Div.	FL	Sol-Heet 1000C	(S)	4.0"	102	4.0"	102
Horizon Enterprises	FL	E.E. 2400-A	(S)	3.25"	83	3.375"	86
Semco Corporation	FL	Tropic Sun FP40	(S)	3.0"	76	3.0"	76
Solar Energy Comp. Inc.	FL	FFBCCS-30	(S)	2.5"	64	2.5"	64
Solar-Eye Prod., Inc.	FL	R-200A	(S)	4.125"	105	4.125"	105
Solarkit of Florida	FL	SQ 15-1	(S)	3.0"	76	3.0"	76
Solar Systems/Sundance	FL	1-13-P	(S)	1.5"	38	1.5"	38
Travco, Inc.	FL	Model MK II	(S)	6.375"	162	6.375"	162
Universal 100 Sol.En.S.	FL	410 BG	(S)	3.8125"	97	3.8125"	97
La-Wela-Wai	HI	L-W-W-1	(S)	3.1875"	81	3.1875"	81
Reynolds Metals Co.	VA	Model 1502	(S)	4.375"	111	4.375"	111

(S) denotes serpentine flow pattern of heat transfer fluid

Total number of models for which dimensional information is available: 12

Range of centerline distances from corners: 1.5" - 6.5" (38 mm - 165 mm)
Average: 3.81" (97 mm)

Other Manufacturers: (No Dimensional Data)

Solar Unlimited, Inc.	AL	Suncatcher H2	(S)
General Energy Devices	FL	Solatron 16-41P	
Solar Development, Inc.	FL	SD-5	(S)
Solar Heater Manufact.	FL	SHM-10	(S)

Category 4, Type M: Inlet and Outlet at Back of Collector

Manufacturer and Location		Collector Model		Centerline Distances from Corners Vertical UL	UR	LL	LR	Horizontal TL	TR	BL	BR
Conserdyne Corp.	CA	S1A	In.	4.5	--	--	3.75	12.9	--	--	5.5
			mm	114	--	--	95	327	--	--	140
Piper Hydro, Inc.	CA	Model 3000	In.	--	3.5	3.5	--	--	2.25	2.25	--
			mm	--	89	89	--	--	57	57	--
National Solar Corp.	CT	NSC 100	In.	3.5	3.5	--	3.5	3.5	3.5	--	10.25
			mm	89	89	--	89	89	89	--	260
Sun-Pac, Incorporated	LA	Sun*Miser SS	In.	3.38	--	--	2.75	3.5	--	--	3.5
			mm	86	--	--	70	89	--	--	89
State Industries, Inc.	TN	SC1-4	In.	--	5.0	5.25	--	--	7.0	7.0	--
			mm	--	127	133	--	--	178	178	--

Total number of models for which dimensional information is available: 5

APPENDIX 7

LETTER SURVEY OF SOLAR COLLECTOR/SYSTEM MANUFACTURERS

Listing of Manufacturers Surveyed and Replies Received

Copies of the attached letter were sent to 40 manufacturers of solar collectors and systems, with a request for assistance with technical literature, installation recommendations, and comments/advice related to the five central dimensional issues set forth in the letter.

A total of 10 replies were received, which represents a response rate of 25%.

Manufacturer's Name and Location	Detailed Reply (Copy Attached)	Telephone Reply	Literature Enclosed
Accurex Corporation, Mountain View, CA	-	-	-
Acorn Sunwave Energy, Concord, MA	-	-	-
Albuquerque Western, Albuquerque, NM	-	-	-
American Solar Heat, Danbury, CT	x	-	x
American Solar King, Waco, TX	-	-	-
Ametek Power Systems, Hatfield, PA	x	-	x
Calmac Manufacturing, Englewood, NJ	x	-	x
C.B.M. Manufacturing, Fort Lauderdale, FL	-	-	-
Chamberlain Manufacturing, Elmhurst, IL	-	-	-
Champion Home Builders, Dryden, MI	-	-	-
Columbia Chase Solar, Holbrook, MA	-	-	-
Contemporary Systems, Jaffrey, NH	-	-	x
Daystar Corporation, Burlington, MA	-	-	-
D.W. Browning, Holly Hill, FL	-	-	-
Energy Systems, Inc., San Diego, CA	-	-	-
Falbel Energy Systems, Greenwich, CT	-	-	-
General Energy Devices, Largo, FL	-	-	x
General Extrusions, Youngstown, OH	-	-	-
Grumman Energy Systems, Ronkonkoma, NY	-	x	-
Gulf Thermal Corp., West Bradenton, FL	-	-	-
Halstead & Mitchell, Scottsboro, AL	x	-	x
Inter Technology, Warrenton, VA	-	-	-
Kalwall Corporation, Manchester, NH	-	-	-
Lennox Industries, Marshalltown, IA	-	-	-
LOF Solar Systems, Toledo, OH	x	-	x
Northrup, Inc., Hutchins, TX	-	-	-
Owens-Illinois, Toledo, OH	-	-	-
PPG Industries, Pittsburgh, PA	-	-	-
Raleigh Manufacturing, Miami, FL	-	-	-
Raypak, Inc., Westlake Village, CA	-	-	-
Research Products Corp., Madison, WI	-	-	-
Revere Solar, Rome, NY	-	-	-
Reynolds Metals, Richmond, VA	x	-	x
Solafern, Bourne, MA	-	-	-
Solar Energy Products, Gainesville, FL	-	-	-
Solaron Corp., Denver, CO	-	-	-
Solar Unlimited, Huntsville, AL	-	-	-
State Industries, Ashland City, TN	-	-	-
Sun Unlimited Research, Sheboygan, WI	-	-	-
Sunworks, New Haven, CT	x	-	x

Copies of selected replies are included in this Appendix.

LETTER SENT TO 41 MANUFACTURERS OF SOLAR COLLECTORS AND SYSTEMS

REPLIES RECEIVED FROM 10 MANUFACTURERS

Dear Sir:

As part of a research investigation into "Dimensional Considerations in Solar Heating and Cooling Applications," sponsored by the U.S. Department of Energy, we are looking at dimensional factors in the design, manufacture, installation, and maintenance of solar systems. Because solar collectors represent a significant design and cost component, a major part of the study deals with considerations involving collectors and collector arrays.

The investigation is designed to assess the following aspects:

a. Practices, limitations, and trends in dimensions and sizes for solar systems and system components;

b. Relationships between dimensions and sizes of solar components, and the design and installation of systems in new buildings or retrofit situations;

c. Dimensional preferences and reasons for such preferences; and,

d. Potential effect of the change to metric measurement in the U.S. building industry.

The objective of the investigation is to determine the merit of preferred dimensions and sizes in solar systems and system components.

To meet the scope of the investigation, the following factors will be studied in detail:

1. Influences determining the sizes, or range of sizes, of individual collectors

   Are collector sizes determined by structural considerations, building design considerations, production constraints (e.g., the size of absorber plate or unit, cover plate, or materials for collector housing), inventory considerations, array flexibility considerations, or by other factors?

   Is it possible to modify collector widths and/or lengths to suit other dimensional preferences (e.g., metric preferred sizes)?

2. Space requirements for a collector within the collector array

   What clearances are required and why? What is the coordinating space (centerline to centerline) for a collector within an array? What arrangements (horizontal and/or vertical combinations) are the most useful for collector arrays?

3. Characteristics of mounting and support systems

   Where are the mounting positions in relation to the collector housing and why? What mounting hardware is recommended? Is a mounting frame required? Is the support system suitable for parallel and/or inclined mounting of collectors?

4. Preferred location of inlets and outlets, connections, and sizes for pipes or ducts

   What flexibility exists in the positioning and sizing at pipes or ducts?

5. Installation recommendations and repair or replacement

   What recommendations are made in relation to weatherproofing of penetrations? What are the procedures for repair or replacement of collectors or accessories, and what clearances do these procedures require?

The investigation is primarily concerned with dimensional considerations and not with functional performance aspects, except as they influence dimensional limitations.

We would very much appreciate your organization's assistance with technical literature, installation recommendations for your system(s), and in particular, any comments or advice you may have on the five topics outlined above.

All replies will be acknowledged in the report to the Department of Energy, and respondents will be provided with copies of the findings of this investigation.

I am looking forward to your cooperation.

Sincerely,

HANS J. MILTON, FRAIA
Technical Consultant
Division 744
Center for Building Technology, NEL

AMETEK

POWER SYSTEMS GROUP • 1025 POLINSKI ROAD, IVYLAND, PA 18974 TELEPHONE (215) 441-8770

June 6, 1979

Mr. Hans J. Milton FRAIA
Division 744
Center for Building Technology, NEL
United States Department of Commerce
National Bureau of Standards
Washington, D.C. 20234

Dear Mr. Milton:

The AMETEK Power Systems Group is pleased to provide you with the following dimensional information.

1. Influences determining sizes
   a. Our collectors are principally sized around the 34" x 96" Olin Brass absorber plate. At 160 pounds per unit the collector can be handled by two people during the manufacturing, shipping, and installation of equipment. There are certain constraints with respect to available glass sizes and required thicknesses.
   We have made no attempts to provide collectors in metric sizes.

2. In the enclosed brochure you will see that we suggest 3/4" spacing between collectors. This allows some latitude for structural tolerances, clearance for protruding fastener heads.

3. The suggested mounting details for our collectors are provided in our brochure. We have also included a detailed structural location drawing. We do not require redundant structural supports along the length or width of the collector.

4. Fluid connections are located at the top and bottom of the collector, both on the same side. This allows for collectors to be installed in series on pitched roofs. Fluid connections are made with high temperature silicone hose or brazed with copper tubing. We do not offer internal manifolding primarily due to the problems associated with absorber plate stagnation and thermal expansion.

JUN 11 1979
#121

5. We leave the details of penetrations to the engineer or solar installer. Glazing of absorber plates can be replaced with the collectors in place without shutting down the entire system.

Please contact me if you have any other questions.

Very truly yours,

Jack F. Nelson
Marketing Manager

JFN:ss
enclosure

AMERICAN SOLAR HEAT CORPORATION
7 NATIONAL PLACE, DANBURY, CONNECTICUT 06810·203·792·0077

June 6, 1979

Hans J. Milton
Technical Consultant to the Center for Building Technology
United States Department of Commerce
National Bureau of Stand ards
Washington D.C. 20234

Dear Mr. Milton:

I refer to your letter of June 1, 1979.

Regarding the configurations for multiple collectors in a system, we do not like to use more than three collectors in a series.

I trust that this will answer your question.

Sincerely

Patricia Shafto
Exec. Vice-President

ps

RECEIVED
JUN 11 1979

CALMAC

· Solar Energy
· Thermal Storage
· Ice Rinks
· Heating

CALMAC MANUFACTURING CORPORATION
150 South Van Brunt Street
Englewood, N.J. 07631
(201) 569-0420 (212) 586-5178

May 21, 1979

Mr. Hans J. Milton
Technical Consultant
Division 744
Center for Building Technology, NEL
United States Department of Commerce
National Bureau of Standards
Washington, D.C. 20234

Dear Mr. Milton:

In response to your request of May 1, 1979 for data on "dimensions" of solar collectors, we enclose our manuals on our Sunmat Collector product line. These contain what data we have.

Our preferred line for the future will be site-built collectors flat on roofs made to fit the available space. These will be much lower cost, somewhat lower efficiency, and using unspaced glazing (no box). We are preparing data on these at present.

Sincerely,

CALMAC MANUFACTURING CORP.

Calvin D. MacCracken
President

CDM:ir

enclosure

MAY 24 1979
#109

Halstead & Mitchell
A DIVISION OF HALSTEAD INDUSTRIES INC.
HIGHWAY 72 WEST
SCOTTSBORO, ALABAMA 35768
205-259-1212

May 17, 1979

United States Dept. of Commerce
National Bureau of Standards
Center for Building Technology, NEL
Washington, DC 20234

Attention: Mr. Hans L. Milton, FRAIA
Technical Consultant

Subject: Dimensional Consideration in Solar Application

REF: Your Letter of May 9th

Dear Mr. Milton:

In response to your letter we are glad to enclose our SunCeiver Catalogs #SC-771, #ICS-77 and A-46444.

Answering your specific questions:

1) Collector sizes are determined primarily by the available glass dimensions. Multiples of these in one collector assembly are feasible.

2) We believe that horizontal arrays are more practical unless otherwise dictated by architectural considerations. Vertical arrays probably would present structural problems which may be costly to solve.

3) Mounting Hardware: We recommend a supporting frame as shown on the back page of bulletin ICS-77. Depending on the application, the tilt adjustment may be omitted. This illustration also gives you a partial answer to your Question #2.

4) We furnish leads located normally as shown in Figure 3 of the enclosed bulletin ICS-77, but on special order the arrangement in Figure 2 is also available. On occassion we have received requirements for back inlet and outlet connections, which are feasible but appear to be impractical.

MAY 21 1979
#496

5) Installation: Our recommendations are summarized on pages 5 and 6 of the enclosed bulletin ICS-77. So far as roof penetrations are concerned, they should be avoided whenever possible, and if unavoidable, they should be sealed by a roofing specialist and not by a plumber or mechanic.

We hope this information will be helpful.

Yours very truly,

HALSTEAD & MITCHELL
A Division of Halstead Industries

Otto J. Nussbaum, P.E.
Director of Engineering & Research

OJN:lvw

Enc. (3)

May 10, 1979

LOF SOLAR ENERGY SYSTEMS
1701 EAST BROADWAY, TOLEDO, OHIO 43605 TEL 419 247-4350

Mr. Hans J. Milton
United States Department of Commerce
National Bureau of Standards
Washington, D.C. 20234

Dear Mr. Milton:

With regard to the letter received concerning "Dimensional Considerations in Solar Heating and Cooling Applications," I am responding with the enclosed literature and the following comments:

1) Influences determining the sizes, or range of sizes, or individual collectors
One of the prime considerations in Libbey-Owens-Ford's decision to go to a 3' x 7' collector was to determine the maximum size collector that could be used with 1/8" tempered glass. The result was that 36" x 84" is the largest size. Also, it fit very nicely into the tempering furnaces that temper our largest volume of patio door size glass, 34" x 76". Another consideration was that 1/8" glass would keep the weight to a minimum.

2) Space requirements for a collector within the collector array.
The space requirements and clearances as questioned under item #2 really have no determination upon the size of the collector. The size of arrays are designed to suit the collector or the area on which the arrays are to be mounted. The most influential factor would be that the largest size collector will require the least number of connections and the least amount of steel support system required for the collectors. This last item may be offset by the fact that the larger the collector the heavier it is, thus requiring a stronger support structure.

3) Characteristics of mounting and support systems
The LOF SunPanel collector usually sits on an extruded aluminum spar or steel angles. When in place, it sits on the top and bottom 1".

MAY 15 1979
#72

4) Preferred location of inlets and outlets, connections and sizes for pipes or ducts
The preferred inlet and outlet on an externally manifolded collector are at the diagonally opposite corners. The unit can also be purchased opposite hand. The collector can be mounted with the three foot or the seven foot dimension horizontal.

5) Installation recommendations and repair or replacement
The LOF SunPanel collector has a fully extruded aluminum frame that has welded corners. We use lock-in caps and EPDM gaskets that are then siliconed. The top cap is locked in place with a wedge. Once the silicone is stripped, the wedge can be removed, thus freeing the cap. After the cap is removed, the broken cover plate can be removed and replaced.

Sincerely,

Lloyd E. Bastian, Manager
Solar Energy Systems

fm
Enclosures

cc:
Mr. M. F. Wenzler
Mr. R. D. Goodman

SUNWORKS
3900
MAILING ADDRESS • P.O. BOX 2000 • SOMERVILLE, N.J. 08876 • (201) 469-0399
OFFICE • CENTRAL JERSEY INDUSTRIAL PARK • BLDG. 1EC • RTE. 22 • BOUND BROOK, N.J. 08805

May 30, 1979

Hans Milton
United States Department of Commerce
National Bureau of Standards
Washington, D. C. 20234

Dear Mr. Milton:

In response to your May 7, 1979 request, please find enclosed information on Sunworks flat plate solar collector line. In answering your questions, let me address them in order:

1. The major influence determining the size of the Sunworks collector line is an optimization of material availability, economy of size, and adaptability to the construction industry. The major determinant in width of the collector is the clear span structural capability of 1/8" and 3/16" tempered glass under an implied load exerted from a 120 m.p.h. wind. A 34" clear span is the maximum acceptable width. Taking into consideration supports for the glass, thickness of the collector container and mounting requirements, the optimum width becomes 35½" in our opinion. Length is primarily determined by the most economical tube and absorber sheet demensions. In so much as most hard drawn tubing is available in 20 feet lengths, the largest multiple would be just under 7'-0" in length. Again taking into consideration header size and connection space to the riser tubes, positioning within the absorber container, frame thickness and mounting requirements, the optimized length becomes 7'-0". Of the two demensions, this is the most modifiable demension. Sunworks has had experience in constructing collectors as small as 5'-4" in length and as long as 8'-0" in length. However, to date 98% of the collectors requested have been of the 7' demension.

2. Spacing requirements for a collector within an array are primarily determined by the tightest distance that a field connection can be accomplished within. Presently that spacing with the Sunworks internally manifolded collector type is 1".

RECEIVED
JUN 11 1979
#125

This particular jointing arrangement has met with very large marketing success primarily because such a connection arrangement significantly reduces installation cost and maximizes the amount of effective collector area per gross collector area in the array.

3. Mounting of the Sunworks collector line is accomplished either by an integral mounting leg at the top and the bottom of the collector which can then be bolted directly to the support structure, or mounting can be accomplished by the use of "U Clips" in the integral key-way in the collector frame. These particular mounting mechanisms allow less connections per square foot of collector area while also allowing a flexability in the support structure with respect to its size. (see details in the enclosed literature)

4. The Sunworks selector line has complete adaptability of piping arrangements. The inlet and/or outlet connections can be placed in any of the four back corners or in the side of the collector frame at any corner yielding a total of 12 potential positions for entry/exit. (see sketch)

5. Please find enclosed a copy of our installation recommendations. I believe this booklet will sufficiently answer this question.

I trust these brief remarks will provide you with the information you are seeking. If you have any further need for information, please do not hesitate to contact me by phone.

Sincerely,

Ryc Loope
Manager Technology and Market Development

RL:cs

APPENDIX 8

DISCUSSION OF THE NEED FOR A MARKET SHARE MODIFIER IN THE ANALYSIS OF COLLECTOR SIZES

A Modifier for Manufacturing Size

Since the flat plate collectors listed in this report have been included simply to reflect available measurement information, rather than quantity produced and/or market share, it is recognized that a comprehensive statistical analysis would have to include a "market share modifier" or k-factor, to give greater weight to collectors that dominate the existing solar market and, therefore, dimensional considerations.

In the absence of reliable production or sales statistics for individual collector models, such a modifier can only be developed in general terms.

Some indication of the impact of certain manufacturers on the solar market is provided by the computerized grant reports in the Department of Housing and Urban Development (HUD) Residential Solar Heating and Cooling Demonstration Program [Cycles 1, 2, 3, 4 and A], listed in March 1979 by the Residential Solar Data Center (SDC) of the National Bureau of Standards (NBS). While this program accounts for only a part of all solar installations in the United States, and excludes commercial/industrial applications, it shows that a total collector area of all systems assisted by federal grants of 588,639 ft^2 [54 686 m^2]. More significantly, the first ten manufacturers whose products have been used account for two thirds of the total area:

Sunworks	112,116 ft^2	[10 416 m^2]	19.05%
Daystar	62,557 ft^2	[5 771 m^2]	10.63%
Solaron	56,733 ft^2	[5 271 m^2]	9.64%
Revere	48,249 ft^2	[4 482 m^2]	8.19%
Miromit	32,454 ft^2	[3 015 m^2]	5.51%
Lennox-Honeywell	28,547 ft^2	[2 652 m^2]	4.85%
Gulf Thermal	13,308 ft^2	[1 236 m^2]	2.26%
Grumman	12,618 ft^2	[1 172 m^2]	2.14%
Raypak	11,693 ft^2	[1 086 m^2]	1.99%
General Electric	9,933 ft^2	[923 m^2]	1.69%
Total for 10 Manufact.	388,208 ft^2	[36 066 m^2]	65.95%

Assuming an average collector area of 22 ft^2, or 2 m^2, the first six manufacturers listed have manufactured over 15 000 collectors for use in the HUD Demonstration Program, with Sunworks alone accounting for 5400 of these and, therefore, introducing a significant dimensional preference in the solar collector market compared with manufacturers whose production is measured in hundreds or tens of units per annum.

With production volumes of over 10 000 units per annum it is feasible to introduce greater industrialization into the manufacturing process; for example, the stamping and forming of collector housings from a single sheet of metal, including all strengthening and prepunched openings for inlet and outlet pipes (or ducts), and anchor points for collector mounting. The emergence of greater standardization within the solar industry is another precondition for industrialization of the manufacture of component parts, such as absorbers, cover plates, insulation jackets, and support frames or racks.

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET	1. PUBLICATION OR REPORT NO. NBSIR 80-2116	2. Gov't. Accession No.	3. Recipient's Accession No.

4. TITLE AND SUBTITLE

DIMENSIONAL CONSIDERATIONS IN SOLAR INSTALLATIONS

5. Publication Date: September 1980

6. Performing Organization Code

7. AUTHOR(S)

Hans J. Milton

8. Performing Organ. Report No.

9. PERFORMING ORGANIZATION NAME AND ADDRESS

Center for Building Technology
NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, DC 20234

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS *(Street, City, State, ZIP)*

Office of Solar Applications for Buildings
Office of the Assistant Secretary, Conservation and Solar [Applications
Department of Energy
Washington, D.C. 20585

13. Type of Report & Period Covered

Final

14. Sponsoring Agency Code

15. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

The Interim Report contains a study of dimensional considerations in solar installations using non-integrated flat plate collectors. Special attention is given to sizes of collectors and their constituent materials, to dimensions that affect the collector array, and to sizes for thermal storage tanks.

One of the aims of the investigation was to assess the scope for future standardization of collector sizes and their configurations, with the object to facilitate the processes of collector design, production and distribution, system design, installation, operation, and maintenance. An additional aspect was to assess the potential impacts of a change to metric units and product sizes in U.S. industry.

The report deals principally with a listing and evaluation of dimensional data for 185 flat plate collectors in production and/or use in 1978, (141 liquid, 37 air, and 8 special types), produced by 152 manufacturers. Measured sizes cover a wide range of width/length combinations, but some preferred sizes can be observed. Solar water heaters have followed standardization patterns of hot water tank manufacturers.

The report suggests that greater standardization of solar systems and components is feasible, and points to some benefits that would result. The report also contains recommendations for follow-up and future investigations.

The Interim Report is intended to provide an overview of trends in the industry in 1978/79, and not an evaluation of individual commercially available components.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Dimensions; flat plate collectors; preferred sizes; solar installations; standardization.

18. AVAILABILITY ☒ Unlimited

☐ For Official Distribution. Do Not Release to NTIS

☐ Order From Sup. of Doc., U.S. Government Printing Office, Washington, DC 20402, SD Stock No. SN003-003-

☒ Order From National Technical Information Service (NTIS), Springfield, VA. 22161

19. SECURITY CLASS (THIS REPORT)	21. NO. OF PRINTED PAGES
UNCLASSIFIED	153
20. SECURITY CLASS (THIS PAGE)	22. Price
UNCLASSIFIED	$11.00

USCOMM-DC